CHAPTER 2

BOILER MAINTENANCE

Learning Objective: Recognize maintenance requirements and procedures for boilers and auxiliary equipment; recognize boiler operation steps and checks and safety requirements.

As a Utilitiesman, it is your responsibility to operate, maintain, and repair boilers. You can perform operator maintenance on shore-based boilers; perform preventive maintenance and minor repairs on boilers and associated equipment; complete chemical tests on boiler water and feedwater; replace defective boiler tubes; test, adjust, and recalibrate boiler gauges and other accessories.

This chapter provides information on some of the methods, procedures, and techniques used to operate, maintain, and repair boilers and associated equipment safely under typical conditions. Because of the broad scope of tasks involved in operating and servicing boilers, this chapter does not tell you all you need to know about the subject. Learning how to accomplish the procedures given in the following sections can help you acquire a basis on which to develop more advanced skills. While the procedures given in this chapter are typical, you should always follow the manufacturer's instructions for the equipment.

MAINTENANCE OF AUXILIARY EQUIPMENT

Learning Objective: Recognize and understand basic auxiliary equipment maintenance.

A well-planned maintenance program is the key to avoid unnecessary downtime or costly repairs, promotes safety, and aids local inspection. An inspection schedule listing the procedures should be established. It is recommended that a boiler room log or record be maintained for recording the daily, weekly, monthly, and yearly maintenance activities. This provides a valuable guide and aids in the operational efficiency, length of service, and safe operation of a boiler. It is also important to remember that improperly performed maintenance is just as damaging to a boiler as no maintenance at all.

MAINTENANCE REQUIREMENTS FOR CONTROL OF WATER LEVEL

The need to check water level controls and the water side of the pressure vessel periodically cannot be overemphasized. Most instances of major boiler damage are the result of operating with low water or using untreated (or incorrectly) treated water. Always be sure of the boiler water level and blow down the water column routinely. Check samples of boiler water and condensate according to procedures recommended by your water consultant (figs. 2-1 and 2-2).

Since the manufacturer generally sets low water cutoff devices, no attempt should be made to alter or adjust these controls. If a low water device should become erratic in operation or if the setting changes from previously established levels, check for reasons and correct it by repair or replacement.

Figure 2-3 is a replica of the low water cutoff plate attached to a steam boiler. These instructions should be followed on a definite schedule. These controls normally function for long periods of time and may lead to laxity in testing on the assumption that normal operation will continue indefinitely.

On a steam boiler, the head mechanism of the low water cutoff devices should be removed from the bowl at least once a month to check and clean the float ball, the internal moving parts, and the bowl or water column. Remove the pipe plugs from the tees or crosses and make certain the cross-connecting piping is clean and free of obstructions. Controls must be mounted in a plumb position for proper performance.

A scheduled blowdown of the water controls on a steam boiler should be maintained. It is impractical to blow down the low water cutoff devices on a hot-water boiler since the entire water content of the system would be involved. Many hot-water systems are fully closed and any loss of water would require makeup and

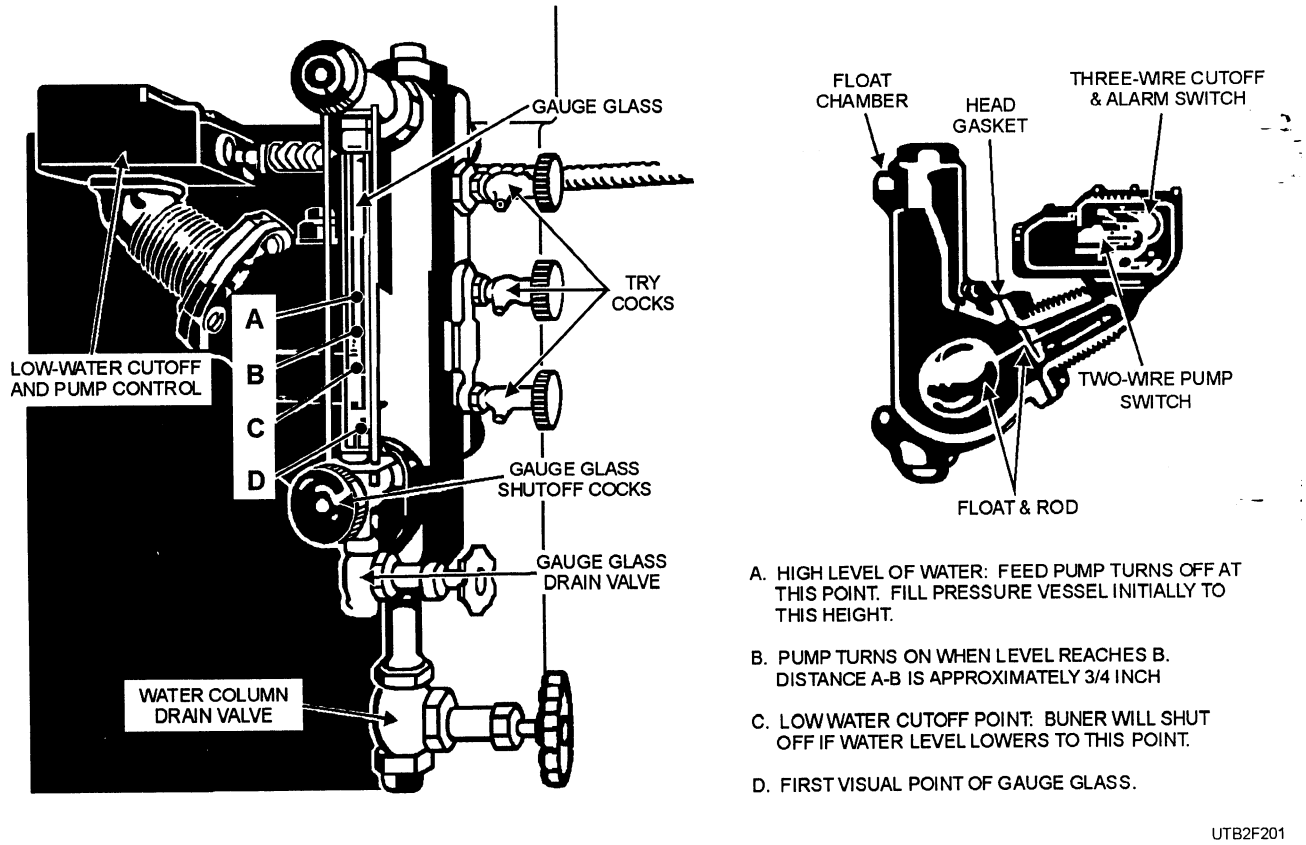

Figure 2-1.—Typical water column and low water cutoff high-pressure steam boiler.

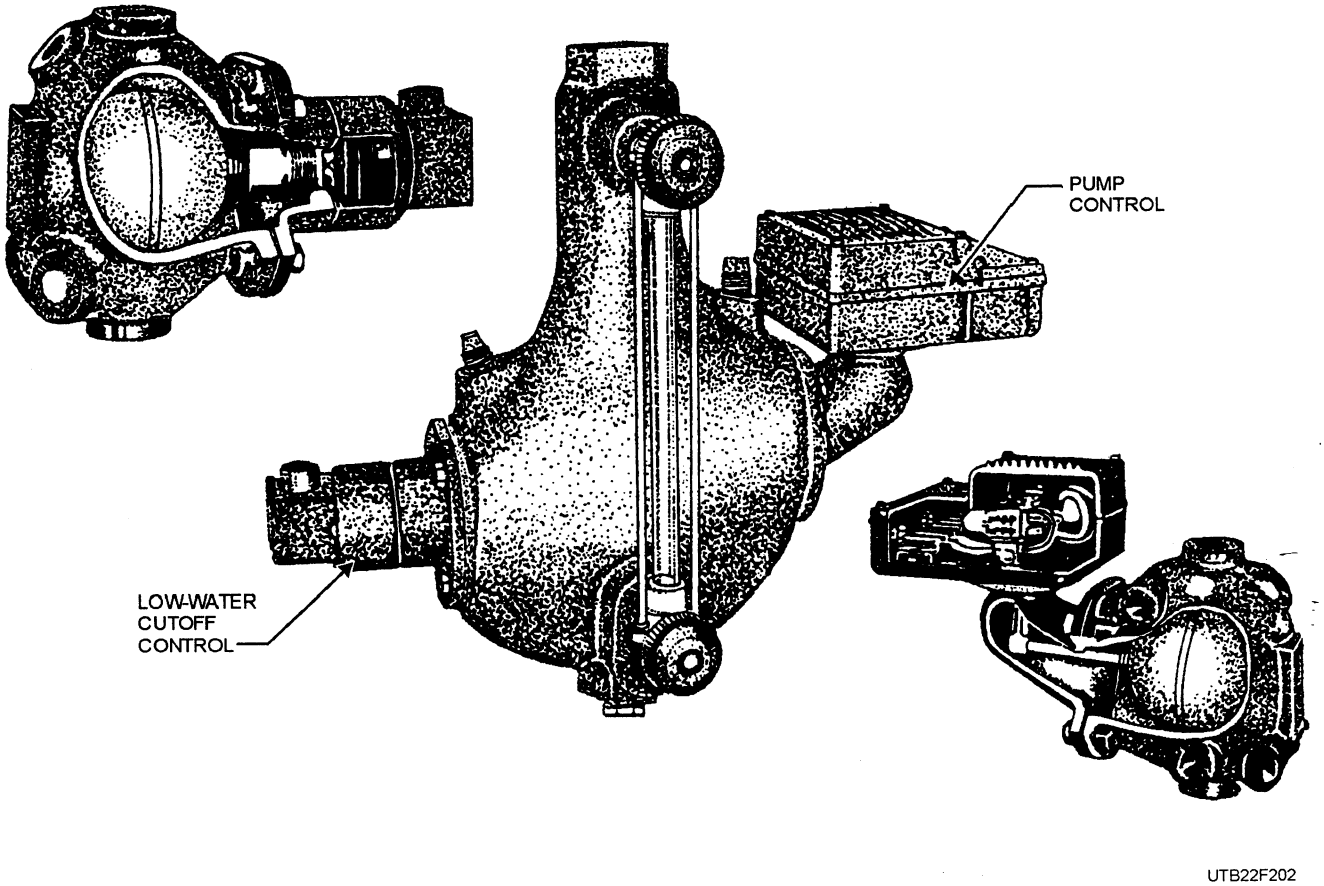

Figure 2-2.—Typical water column for low-pressure boiler.

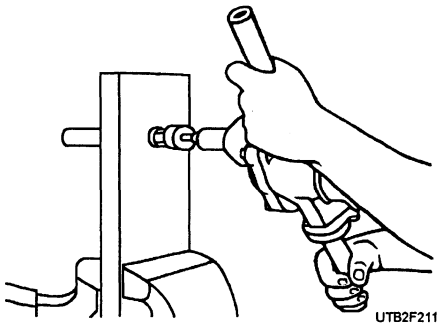

Figure 2-3.—Low water plate.

additional feedwater treatment that might not otherwise be necessary. Since the boiler and system arrangements usually make it impractical to perform daily and monthly maintenance of the low water cutoff devices, it is essential to remove the operating mechanism from the bowl annually, or more frequently if possible, to check and clean the float ball, the internal moving parts, and the bowl housing. Also, check the cross-connecting piping to make certain that it is clean and free of obstructions.

GAUGE GLASS REPLACEMENT

A broken or discolored gauge glass should be replaced at once. Always use new gaskets when replacing a gauge glass. Use the proper size rubber packing. Do not use "loose packing" that could be forced below the glass and possibly plug the valve opening.

Close the valves when replacing the glass. Slip a packing nut, a packing washer, and a packing ring onto each end of the glass. Insert one end of the glass into the upper gauge valve body far enough to allow the lower end to be dropped into the lower body. Slide the packing nuts onto each valve and tighten.

If the glass is replaced while the boiler is in service, open the blowdown valve and slowly bring the glass to operating temperature by cracking the gauge valves slightly. After the glass is warmed up, close the blowdown valve and open the gauge valves completely. Check the try cocks and gauge cocks for freedom of operation and clean them as required. It is imperative for the gauge cocks to be mounted in exact alignment. If they are not, the glass will be strained and may fail prematurely.

FEEDWATER REGULATOR MAINTENANCE

Proper control of the water level requires that the feedwater regulator be maintained. Here are a few pointers for regulators.

If the water level changes from its normal position, make sure you adjust the bypass to manual operation and check promptly for the source failure. If leaks develop around the packed stems, see that they are stopped immediately. If the boiler is off line, close the hand valve in the feed line. Bear in mind that the regulator is not designed for use as a stop valve. About once every 3 months, you will probably be called on to assist in blowing down the steam and water connections separately.

VALVE MAINTENANCE

Valves deserve special care and attention if they are to work as intended. There may be variations among activities in the type and frequency of valve inspection and servicing requirements. Therefore, follow instructions issued by your activity when they differ from those outlined here.

Types of valves that you may be responsible for helping service and maintain at regular intervals include (1) stop valves of the globe or gate type and (2) stop-and-check valves, which combine in one tray and angle or stop valve of the globe type and a check valve. At least once every 3 months, valves that have not been operated for some time should be operated to prevent sticking. Make sure that you also check for leaks, bent stems, a missing or broken handle, and lubricate the exposed threads and gearing of the valve stem.

Loosen and lift the packing follower about once every 3 months or more often if possible. Lubricate the packing with graphite bearing oil or graphite bearing grease. Replace the packing followers and tighten sufficiently to ensure against leaks.

BLOWOFF or BLOWDOWN VALVES should be opened at least once a day. There are four reasons for using these valves:

1. Controlling high water
2. Removing sludge and sediment
3. Controlling chemical concentrations in the water
4. Dumping a boiler for cleaning or inspection

The amount and frequency of blowing down depends on a chemical analysis of the water in the boiler and operating conditions.

On a quarterly basis, inspect the blowoff valves when the boiler is washed out and an internal inspection is made. Check the valves for leaks, and inspect the pipe and fittings between the blowoff

valves and the boilers. If repairs are needed, see that they are made promptly. In making a quarterly check on the blowoff valves, do not overlook the insulation, bearing in mind that it should be kept dry. Another item is the discharge piping leaking from the valves. Make sure the discharge piping is not mounted so rigidly that proper expansion and contraction are affected.

Keep SAFETY VALVES (fig. 2-4) in top working order. At regular intervals, depending upon operating conditions, the safety valves must be lifted manually. At least once each year the valves should be tested by raising steam pressure to popping pressure of the respective valve. If safety valves function improperly, promptly report the matter to your immediate supervisor. For detailed information on the maintenance of safety valves, refer to manufacturer's manual.

STEAM INJECTOR MAINTENANCE

With injectors, little maintenance is required. At times you will have to reseat the overflow and ring valve. Lime deposits also can reduce the operation by closing down the size of the combining and delivery tubes. A good way to remove lime deposits is to place the injector in a tube of muriatic acid for several hours.

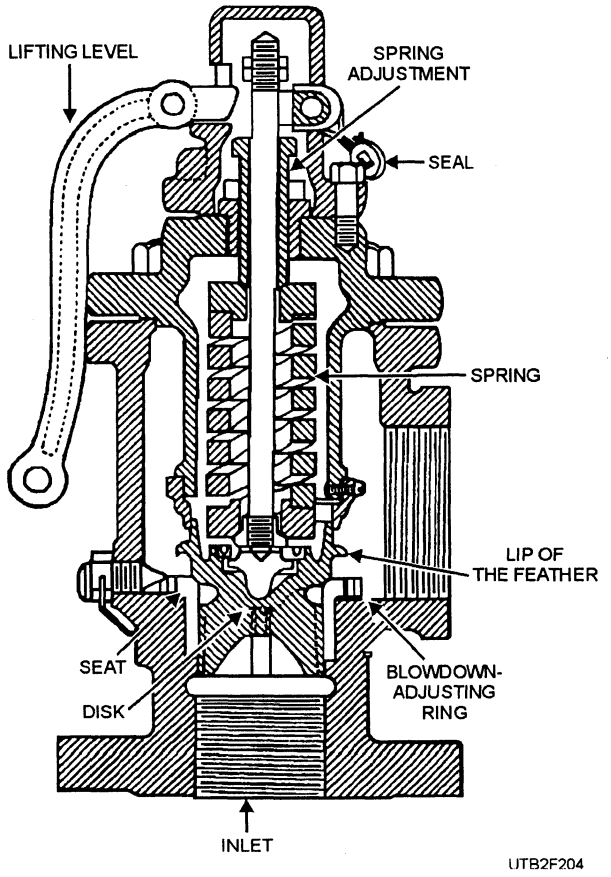

Figure 2-4.—A typical spring-loaded safety valve.

To clean the injector, remove the bottom plug (fig. 2-5). The delivery tube and ring valve drop out. Examine and clean all passages and holes. After cleaning, replace them in the plug (which acts as a guide) and screw tightly in place.

STEAM TRAP MAINTENANCE

Once each month, see that steam traps are tested for correct operation. Methods used in testing steam traps (such as the test valve method, the glove test method, etc.) are discussed in another section of this training manual.

Once a year, or more often if required, dismantle and clean all traps. Inspect for the following:

1. The accumulation of foreign matter
2. Plugging of orifices, valves, and vents
3. Cracked, corroded, broken, loose, worn, or defective parts
4. The excessive wear, grooving, and wire drawing of valves and seats
5. Defective bellows, buckets, or floats
6. Leaky vessels and pipes
7. Defective bypass valves

Repair or replace defective parts as required following yearly inspection. Replace or repair all

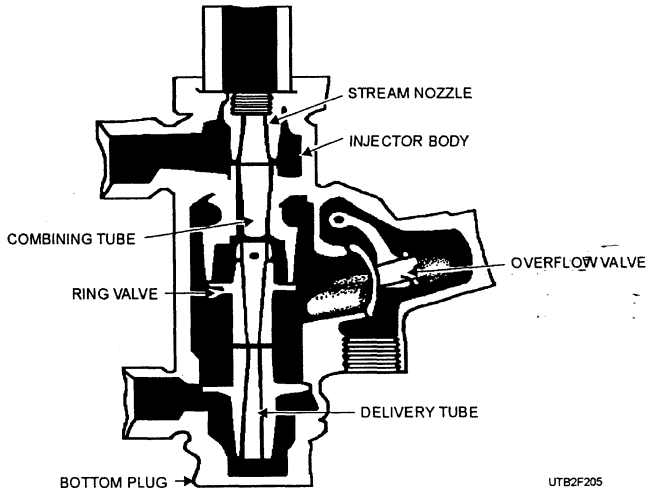

Figure 2-5.—A cross-sectional view of an injector.

defective gaskets, bellows, valves, valve seats, floats, buckets, linkages, and orifices. Use only matched sets of replacement valves and seats. Make certain all replacement parts are of the correct size. Do not change the weight of floats or buckets when repairing traps, or operation may be affected. Often, it is more economical to purchase and install new parts than to recondition defective elements. Repair or replace leaking bypass valves. Repack valve stems.

FAN MAINTENANCE

The forced-draft fan should be checked daily to prevent an accumulation of dust in or around the fan. KEEP THE FAN CLEAN! Also, check daily on the sound of the fan. If it is not normal, report the matter promptly to your supervisor.

A daily check should also be made to ensure adequate lubrication of the fan. The temperature is another item that should not be overlooked. This you can test by feel. In case of excessive temperature, notify your supervisor immediately.

Because induced-draft fans are exposed to hot, dirty gases, they must be observed closely to prevent operating difficulty. Taking proper care of the fan requires DAILY attention to ensure that the following conditions are met:

1. Bearings are kept cool and well lubricated.
2. Fan is kept clean. Also, see that any change from the normal in sound is reported promptly to your supervisor.

HANDHOLE AND MANHOLE GASKET MAINTENANCE

At each regular boiler overhaul, all handhole and manhole fittings and gasket seating surfaces on the drums and headers must be cleaned, inspected, repaired, or renewed if necessary. If the plates are warped, distorted, or otherwise damaged, they must be repaired or renewed.

Whenever handholes and manholes are opened, new gaskets must be fitted. After a gasket has once been compressed, it must be discarded, as it will not provide a seal. Be sure to use the correct size and type of gasket. Never use any makeup compound on the seating surfaces when installing the gaskets. Graphite may be used on the threads of the stud to prevent seizure of the nut.

Before installing a new gasket, thoroughly clean the two gasket seating surfaces (one on the drum or header and one on the plate). Be sure you remove all the corrosion or other surface deposits and all adhering pieces of the old gasket. It is impossible to obtain a tight joint as long as any foreign matter remains on either seating surface or in the corners of the fitting. Be sure to water-soak the new gasket for 24 hours before installation.

Power-driven wire brushes are best for cleaning the seating surfaces. Scrapers should be used only when wire brushes are not enough to clean the surface. Scrapers must be used with great care, if they are used at all, since they tend to remove too much metal from the seating surfaces.

If the gasket seating surfaces show a lot of pitting, you may have to get these surfaces machined or reground. If the seating surface on a handhole or manhole plate is badly pitted or damaged, discard the plate and replace it with a new one or one that has been machined to blueprint specifications.

The clearance between the shoulder of a manhole plate and the manhole must not exceed one-sixteenth of an inch when the plate is centered accurately. Figure 2-6 shows where the clearance is measured. If the clearance is greater than one-sixteenth of an inch, the plate should be built up by electric welding at the inner edge of the shoulder. Steelworkers should do the welding, so the manhole plate may be stress-relieved after it is welded and the welded surface may be remachined.

To position a manhole gasket properly, fit it on the long axis until the inner edge of the gasket fits the shoulder snugly at the ends of the long axis of the manhole plate. The clearance between the gasket and the shoulder should be equalized at the top and bottom of the short axis. Do NOT allow the outer edge of the gasket to protrude at any point beyond the gasket-seating surface in the drumhead. If an edge protrudes, the gasket may unravel when it is compressed by the tightening of the manhole cover. Discard any gasket that protrudes beyond the edge of the gasket-seating surface.

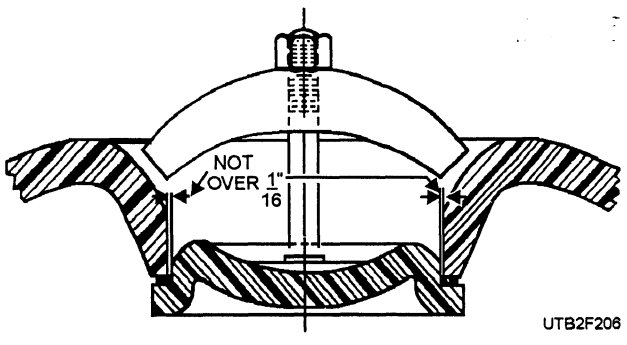

Figure 2-6.—Manhole plate clearance.

To install a manhole or handhole plate, first center the fitting in the opening. Make sure the shoulder does not bind on the edges of the opening. Then slip the yoke on and start the stud nut. Run the nut on the stud until it is hand tight; then give the nut one-quarter of a turn with a wrench. Do NOT tighten the nut enough to compress the gasket.

When the boiler is given a hydrostatic test, the pressure of the water usually forces the manhole and handhole gaskets into place and thus ensures proper seating. The plates are first set up lightly. When the boiler is ready for testing, the pressure should be pumped up to within 50 psi of the hydrostatic test pressure, regardless of any leakage from the manhole or handhole plates. Leakage is likely to be general at first, but it decreases as the pressure is increased. When the pressure is within 50 psi of the test pressure, most of the leakage stops although the nuts are still loose.

If some plates are leaking badly, the trouble is probably caused by improper seating of the gaskets. As a rule, the gasket is caught on the outer edge between the edge of the plate and the edge of the counterbore for the seat. A light blow with a hammer on the outside of the plate usually relieves the tension on the gasket and allows it to seat properly.

After leaky gaskets have been adjusted and while full test pressure is on the boiler, tighten up all plates firmly. Use only the wrenches specified for this purpose.

Some economizer headers and a few superheater headers are fitted with handhole plugs instead of handhole plates. Also, some economizers have bayonet types of cleanout plugs on the front ends of the tube loops to allow access to the tubes at the return bend end. Detailed instructions for installing and removing the plug type of manhole fittings and the return bend cleanout fittings are given in appropriate manufacturer's technical manuals.

HYDROSTATIC TESTS

The boiler should be given a hydrostatic test annually or whenever the operator doubts the boiler strength. The purpose of the test is to prove the TIGHTNESS of all the parts of the boiler or the STRENGTH of the boiler and its parts.

In preparing the boiler for a test, rinse it out with fresh water. Then check carefully to see that no loose scale or tools are left in any part of the boiler.

The procedures for making boiler hydrostatic tests are as follows:

1. Close all openings and "gag" (clamp down) all safety valves. Gags should be only hand tight and straight. Do NOT use a wrench; it will bend the valve stem and possibly damage the seat. Remember that valves are easily damaged if lifted by water pressure. Close all connections on the boiler except air cocks, test pressure gauge, and valves of the line through which pressure is to be applied.
2. Reduce the water level in the boiler by opening an air cock, and blow down the boiler until the water level is below the feedwater inlet connection. Clear the blowdown area before blowdown.
3. Connect a hydrostatic pump between the boiler and water service connection. Install all pipe and fittings between the pump and the boiler. Remember, the pipe and fittings must be able to withstand test pressures. Install a hose between the pump and the chosen water service. Ensure the chosen water service supplies ample water pressure to conduct the test.
4. Remove the plug from the feedwater inlet cross by turning it in a counterclockwise direction.
5. Open the boiler casing access doors or plates, so tube ends can be inspected during the test.
6. Install a wedge between the control switch and the pressure-actuating platform. Also, install a stop valve before the control switch to protect the control, so hydrostatic pressure will not actuate or damage the control. The range of the pressure control is usually less than the hydrostatic pressure being applied. Do NOT bend or damage the actuating parts.
7. Fill the boiler with water until water discharges out of the air cock; then close the air cock. Ensure all the air is expelled from the boiler before closing the air cock. Turn on the water service valve. The water temperature should be the same as the surrounding atmosphere. The minimum water temperature must be 70°F.
8. Check the boiler steam pressure gauge in-line cock to ensure that it is open. Ensure the butterfly handle is in-line (parallel) with the tubing.

9. Apply water pressure of 1 1/2 times the maximum allowable working pressure. To avoid rapid shock and strain, bring this pressure up in 10 equal increments, inspecting for leaks and deformities at each increase.

10. Inspect tube ends, boiler seams, pressure fittings, and connections. Make the corrections and repairs wherever possible. In case of unusual conditions, DISCONTINUE the test IMMEDIATELY and NOTIFY YOUR SENIOR PETTY OFFICER. Do NOT exceed the test pressure. NEVER apply more than 10 pounds of pressure above the maximum working pressure on a low-pressure boiler. Consult the ASME code for testing procedures for other than welded steel boilers.

11. Secure pressurizing connections at the required test pressure. Continually inspect the boiler tubes, seams, fittings, and connections. If the boiler and fittings are tight, the pressure should NOT drop more than 1.5 percent in 4 hours. If loss of pressure is over 1.5 percent, find the leak(s) and make the repairs.

Following all hydrostatic testing, steam pressure is raised to lift safety valves and to determine the fitness of the boiler for use.

Q1. Most cases of major boiler damage is caused by what operating condition?

Q2. What could happen if "loose packing" is used on a gauge glass?

Q3. What are the four reasons for using blowoff or blowdown valves?

Q4. What is the purpose of a hydrostatic test on a boiler?

BOILER TUBES

Learning Objective: Recognize and understand methods for renewing, repairing, and cleaning boiler tubes and sheets.

For any boiler retubing job, it is absolutely essential to use tubes that conform in every way to the tube requirements of the particular boiler. Boiler tubes are NOT identical. They differ in such important characteristics as composition of the metal, outside diameter, wall thickness, length, and curvature.

Much of the required information on sizes, thickness, and number of tubes per boiler is given in the manufacturer's technical manual. Some of the information is under the heading of "Tube Data." More detailed information is usually given on the drawings included in the manual.

COMPOSITION OF BOILER TUBES

Generating tubes are usually made of low carbon steel. They may be either seamless or resistance-welded. Seamless tubes were once definitely preferred for naval use. However, improved methods of manufacturing the welded tubes have led to an increased use of welded tubes in naval boilers. Repair ships, tenders, and other naval activities that use, handle, or issue plain carbon steel tubes have been instructed to make no distinction between the seamless and the welded tubes, but to stock, issue, and install them interchangeably without regard to the method of manufacture.

Superheater tubes usually are not made of plain low carbon steel. On boilers where the superheated steam temperature reaches 850°F or higher, the superheater tubes may be made of carbon-molybdenum steel, chromium-molybdenum steel, or an 18-8 chromium-nickel (stainless) steel.

To find detailed information on the composition of the metals used for generating tubes and superheater tubes in any particular boiler, check the manufacturer's technical manual. The information may be given on the drawings, or it may be included in the text.

Once you have found information on the composition of the metals used for boiler tubes, your next problem is to understand it. Do you know what it means when you see "mild steel" on a blueprint? Can you identify metals by their chemical symbols? Do you know what an "alloy steel" is, or anything about the different kinds of alloy steels? Do you know anything about the various systems of classifying steels? Do you know why different steels are used for different kinds of tubes? Answers to these questions are necessary before you can make much sense out of the information you are likely to find on blueprints on the composition of boiler tubes.

Although we all have a general idea of what we mean by the word *metal* it is not easy to give a simple, accurate definition. Chemical elements are metals if they are lustrous, hard, good conductors of heat and electrcity, malleable, ductile, and heavy. In general, these properties of hardness, conductivity,

malleability, and so forth, are known as metallic properties, and chemical elements that possess these properties are generally called metals. Chemical elements that do not possess these properties are called nonmetals. Oxygen, hydrogen, chloring, and iodine are a few examples of nonmetallic chemical elements. A few chemical elements behave sometimes like metals and sometimes like nonmetals. These elements are often called metalloids. Carbon, phosphorus, sulfur, and silicon are examples of metalloids.

Most types of steel look quite a lot alike, so you cannot go by appearances. On Navy blueprints and on drawings furnished in the manufacturer's technical manuals, materials are usually specified by federal or military specification numbers. In addition, the blueprints and drawings may refer to a commercial classification system, such as the Society of Automotive Engineers (SAE) system or the American Iron and Steel Institute (AISI) system.

Federal or military specifications usually require the tubes to be identified by some marking system. For example, one specification for boiler tubes requires that boiler tubes 1 1/4 inches or greater and 3 feet in length be legibly marked by paint stenciling, while smaller or shorter tubes may be bundled and tagged. Another boiler tube specification requires the tubes to be marked by ink stenciling approximately 3 inches from each end and again in the middle of the tube. As a general rule, boiler tube identification markings must include (1) the name or trademark of the manufacturer, (2) the heat number, (3) the class letter, (4) the specification number, and (5) the outside diameter, the wall thickness, and the length.

RENEWING TUBES

Boiler tubes should be replaced when they cannot be made tight, or when they are warped, or otherwise seriously damaged. As a general rule, boiler tubes should not be straightened in place; leaks may develop that could cause permanent damage to other parts of the boiler. Occasionally, however, you may find a screen tube or a wall tube that has bowed out of position for no apparent reason; you can straighten the tube in place and re-roll it if a replacement tube is not available. Tubes that have bowed out of position because of low water SHOULD NOT BE STRAIGHTENED.

To renew tubes in the A row, the corresponding tubes in the B row must also be renewed, regardless of their condition. Similarly, whenever superheated tubes are renewed, remove the superheater support tubes when they are not accessible without removal of the superheater tubes.

General renewal of tubes in a boiler should not be undertaken without approval of the battalion or base commander. The commander's decision as to whether to approve a general renewal of the tubes will be based on the results of inspection and examination of tube samples.

Before beginning to renew tubes, be sure all preparations have been made. Be sure the right types of replacement tubes are available and that all tools and equipment required for the job are on hand and in good working order. Check the cutters, the air hoses, and the fittings for the pneumatic tools, the tube benders, the electric equipment, and the staging.

The steam drum must be opened and some fittings removed to allow access to the ends of the tubes. Also, the water drums and headers must be opened. Any fittings removed from the drums should be carefully set aside and marked, if necessary, to ensure correct replacement.

Before allowing a person to enter the boiler, be sure all safety precautions are observed. Make it your personal responsibility to see that all cross-connecting valves between the boiler being retubed and any steaming boiler are closed and locked or wired shut and are tagged DANGER. DO NOT OPEN. Be sure, also, that the control valves of the steam-smothering system are locked in the CLOSED position. See that enough ventilation is provided; keep portable blowers running at all times while people are working in the boiler. Do not allow unauthorized types of lights in the boiler. Flashlights are preferred for boiler work. If portable lights are used, the electric leads must be thoroughly insulated and the portable fixture itself must be the grounded, watertight type. Before use, portable lights should be checked by an electrician to ensure they are safe.

REMOVING TUBES

Using an air-powered side-cutting chisel (fig. 2-7) ground, cut the old tube flush with the drum or header. Carefully work the cutter so as not to damage the surface of the drum or header. When you are removing superheater tubes, it will be impossible to cut the tube flush with the header with a side-cutting chisel. An expandable fly cutter must then be used to cut out the tubes.

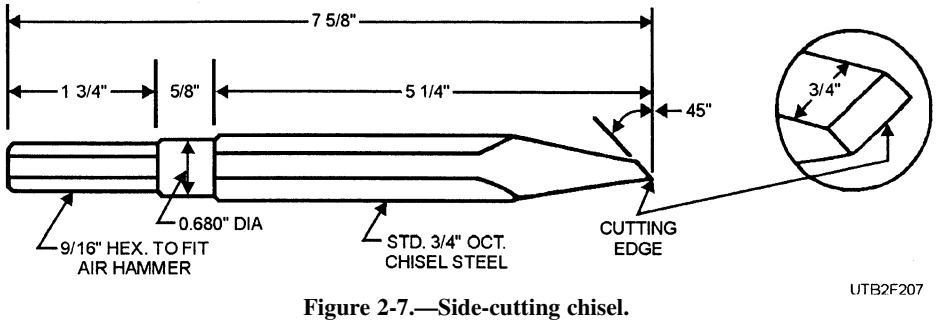

Figure 2-7.—Side-cutting chisel.

After removing the main part of the tube from the boiler, use a safety ripping chisel of the type shown in figure 2-8 to make a cut on the inside of the remaining portion of the tube. The safety ripping chisel is designed so it cannot cut entirely through the tube; therefore, it cannot score the tube sheet.

After cutting the tube approximately three fourths of the way along the tube sheet, crimp the edges of the tube and drive out the stub with a blunt chisel. If the tube is a large one, you may have to make two cuts with the safety ripping chisel instead of one; the cuts should be about an inch apart.

If a safety ripping chisel is not available, you can remove the tube by the following method:

1. Split the ends of the tube with a flat chisel, from the end of the tube to the drum or header, at two places about three fourths of an inch apart.
2. Force the 3/4-inch piece upward with a bar until it has been raised off its seat and has curled into the tube.
3. Split the tube to a point beyond the other side of the tube seat with a tool ground to conform to the tube hole. Be careful not to damage the tube hole.
4. Break in the ends of the tube with a crimping tool, and then drive out the stub.

Arc welding equipment can be used as an aid to the tube removal on some boilers. This procedure requires running two beads, three fourths of an inch apart, through the entire tube sheet, quenching with water, and then using a backing-out tool. Do NOT use this method of tube removal if the drums or headers are made of 4-6 chromium steel.

CLEANING TUBES

Replacement tubes must be thoroughly cleaned to remove all scale, dirt, and preservatives. One way of cleaning a tube is to push a kerosene-soaked rag through it and wipe the outside of the tube with a similar rag. Diesel oil may also be used. If a large enough tank is available, boiler tubes may be cleaned by immersing them in an approved cleaning solution, such as a saturated solution of boiler compound in hot water, to which a small amount of kerosene has been added. Boiler tubes may also be cleaned with steam jets.

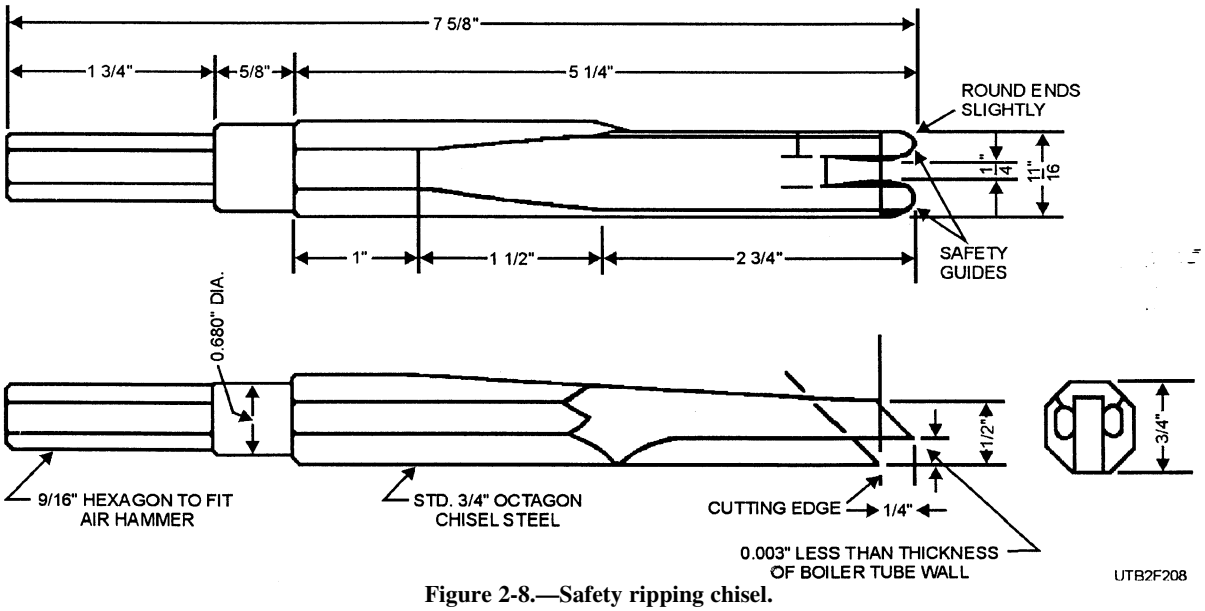

Figure 2-8.—Safety ripping chisel.

PREPARING TUBE SHEETS

The tube sheet holes must be prepared before replacement tubes are inserted. The best way is to use a piece of hardwood turned to a diameter slightly less than the diameter of the hole and covered with a medium fine-grit emery cloth. Pass the wooden piece in a circular motion, back and forth through the tube sheet or header holes to smooth the surface. Finish the job by using a fine emery cloth wrapped around your finger. Keep working until the hole is clean and smooth.

When preparing tube seats, check the size and trueness of the tube holes; use a tube nipple of corresponding size as a template. It is impossible to make tube seats tight if the tube holes are much enlarged or if they are too elliptical (out-of-round). To ensure the tightness of the tube seats, be sure that the maximum enlargement and the maximum ellipticity of the tube holes do not exceed the figure shown in table A, appendix II.

REPAIRING TUBE SHEETS

Out-of-round tube holes, small steam cuts, and other minor defects may, in some cases, be corrected by welding. NAVFAC approval is not required for this type of welding repair on drums and headers made of low carbon steel, carbon-molybdenum steel, or steel containing less than 1 percent chromium if a qualified welder uses approved welding procedures for the welding, filler metal, and position of welding under MIL-STD-248. Always check the blueprints for the material of the drums and headers before welding.

PREPARING TUBE ENDS

After the tubes have been thoroughly cleaned, prepare the tube ends inside and outside. Clean the ends with a wire brush and polish them with abrasive paper and a liquid cleaner until the tube ends are completely clean, free of burrs and mill scale, and thoroughly polished. Clean and polish the tube ends for a distance equal to the thickness of the tube seat plus 2 or 3 inches.

Round off the tube ends with a file, so no square or sharp edges remain. If the tubes are not rounded off at the ends, the tubes may split when they are belled.

FITTING TUBES

When installing tubes, always fit the tubes into the steam drum before inserting the other end in the water drum or header. Inserting the tubes into drums and headers is not particularly difficult, since all tube holes are drilled normal to the tube sheet.

If you are renewing a complete row of tubes, fit a tube at each end of the row and then work toward& middle. You may find slight differences in the lengths of tubes required, if the boiler has been in service for some years. These differences are more likely to show up at the ends of the rows than in the middle.

When fitting tubes into drums or headers, be sure each tube extends far enough into the header or drum. Tubes up to (but not including) 2 inches in outside diameter (OD) should project 3/16 to 5/16 inch into the drum or header. Tubes 2 inches OD and larger should project 5/16 to 7/16 inch into the drum or header.

After you have fitted a tube and allowed for the amount it must project into the steam drum and into the water drum or header, remove the tube and cut off the excess. You may be able to use one tube as a guide for cutting off the excess on several other tubes; if you recall, the tubes may vary slightly in length, particularly in older boilers. Do NOT use one tube to measure the rest of the tubes in a row if you believe there are big differences in tube lengths in the row. If your sample tube happened to be a little on the short side, you would end up with a whole row of tubes that were too short; therefore, they could not be used.

Each tube must be carefully aligned with the other tubes. Use a plywood batten about 1/2 inch thick, 3 feet long, and 3 inches wide to align tubes in the generating bank. After positioning the tubes, check them with the batten. Then place small, wooden wedges to hold the tubes in place until they have been expanded into the tube sheets. Be sure to remove the batten and the wedges before starting work on the next row. These wooden pieces cannot be left in the boiler. You will have a real job on your hands if, after installing five or six more rows of tubes, you suddenly discover that you have overlooked the batten or one of the wedges.

EXPANDING TUBES

The basic joint in boiler construction is an expanded joint that must not leak nor lack holding power. Leakage, if permitted to go uncorrected, leads to deficiency of holding power because of deterioration of the tube seat. Slight leakage itself should not be taken as cause for alarm, but rather as evidence to correct the fault as soon as possible. Deficiency of holding power causes the tube to pull out of its seat. In most cases, the tubes are installed within the furnace of the boiler, and any danger to personnel, if the tubes pull out of the seat, is reduced since the

steam will be discharged up the stack. For this reason, tubes 1-inch-outside diameter (OD) up to and including 2 inches OD are expanded by "boilerman's feet" as only a small amount of expansion is required to hold the tubes firmly in place. With tubes 3 inches OD and larger and all external downcomers, special precautions must be taken to ensure the tubes are properly expanded in the tube seat. Through a series of tests, the point of maximum holding power for various sizes of tubes has been found and is expressed in terms of standard diameters that should be measured after the tube has been expanded in place. In new construction or replacement of tubes where the tube and hole measurements can be obtained, the correct amount of expansion can be found by using the following formulas:

For tubes in drums: Diameter of tube hole minus OD of tube, plus 0.012 inch per inch OD of tube.

For tubes in headers for boiler design pressure under 500 psi: Diameter of tube hole minus OD of tube, plus 0.015 inch per inch OD of tube.

For tubes in headers for boiler design pressure over 500 psi: Diameter of tube hole minus OD of tube, plus 0.020 inch per inch OD of tube.

The figure arrived at by using the above formulas should be added to the OD of the tube as measured to give the required OD of the tube after rolling.

If it is impossible to reach the outside of the tubes in drums to gauge them, the inside diameter (ID) of the tube must be mea sured. Since the plastic deformation of the tube wall varies with tube wall thickness, the ID of the tube for different wall thickness will vary. Where the outside of the tube is inaccessible, the following formula is used in the expansion of a tube:

The ID of the tube, plus the tube hole diameter minus the OD of the tube plus the expansion increase factor.

Boiler tubes should be expanded with the expanding equipment furnished to the shop. Select expanders of the proper size for the tube size and the seat thickness and expanders proper for the operation to be perform ed.

There are two types of expanders: roller-type and ball-drift type. Roller-type expanders are furnished for use by the shop labor force. Roller-type expanders are shown in figure 2-9. A series of adapters are furnished for use if tube holes are not readily accessible. Some of these adapters are shown in figure 2-10.

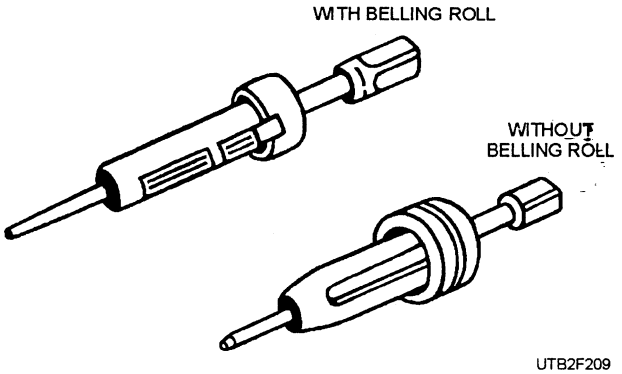

Figure 2-9.—Roller-type tube expanders.

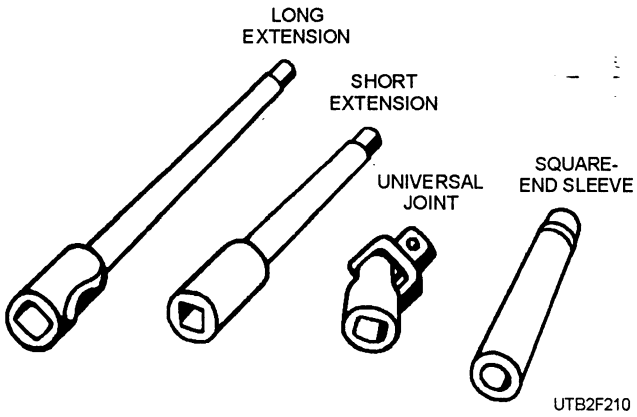

Figure 2-10.—Adapters for tube expanders.

Tube expanders are operated by air motors. The air, at about 100 psi, enters through a controlling handle and goes into the motor housing where it drives an air turbine. The turbine is attached to the shaft of the motor. The controlling handle can be turned clockwise or counterclockwise. A chuck with a tapered shank engages the shaft of the air motor, thus transmitting the power of the motor to the rollers used for expanding tubes into the tube sheet.

Both the air motors and the chucks are available in various sizes. The large sizes of motors and chucks are used for expanding the larger sizes of tubes. Figure 2-11 shows a tube expander in use.

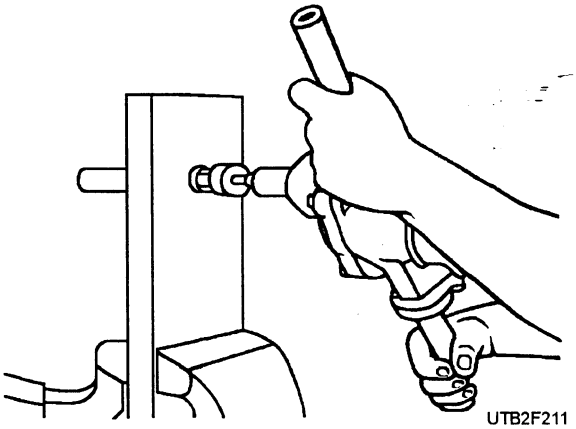

Figure 2-11.—Expanding a tube.

Tube expanders must be used carefully to avoid damage to the expanders and to prevent injury to personnel. The centrifugal force developed by the air turbine is great, so the air motor must be gripped firmly with both hands. If the roller-mandrel combination should bind, the force of the air motor could break the mandrel and quite possibly cause injury to the operator. Always have a person stationed nearby to give immediate assistance if necessary. If you run into any trouble, your safety person may be able to crimp the hose quickly and thus keep the mandrel from breaking.

BELLING TUBES

Most tubes are expanded and belled. However, check the drawing to determine if any specific instructions are shown. Some tubes in 1,200 psi boilers are lightly expanded or belled before welding; some are directly butt-welded to the studs. A roller-type or a drift-type belling tool is used. The drift-type tool is shown in figure 2-12.

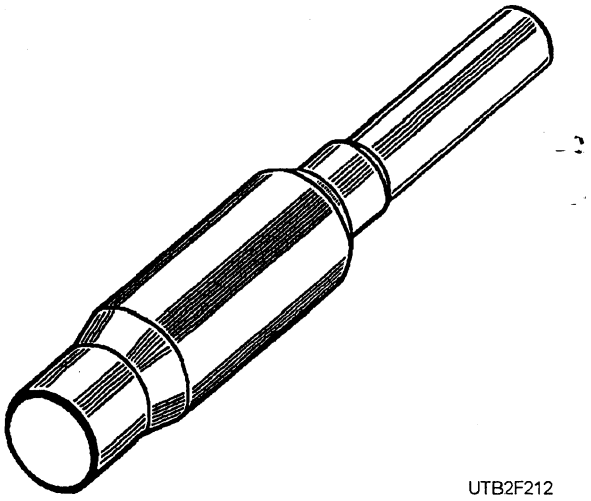

Figure 2-12.—Belling tool.

When belling a tube, be careful not to overdo the operation. Tubes up to, but not including 2 inches OD should be belled at least 1-15 inch but no more than 1/8 inch. Tubes 2 inches OD and larger should be belled at least 1/8 inch, but no more than 3/16 inch. The increase is to be measured over the outside tube diameter at the end of the tube. Figure 2-13 shows the process of belling a tube.

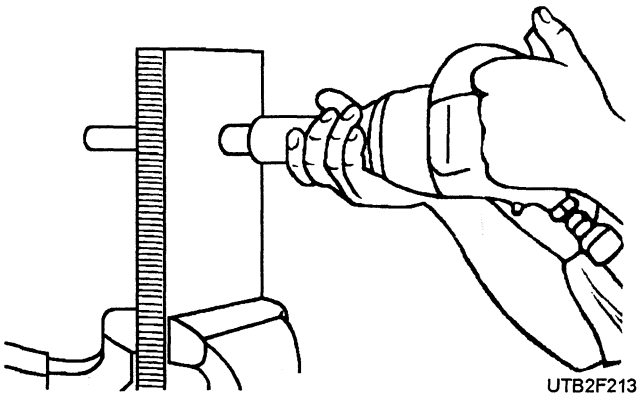

Figure 2-13.—Belling a tube.

Some expanders are fitted with belling rolls, as shown in figure 2-9. When these expanders are used, the tubes are expanded and belled at the same time; thus, there is no need for a separate belling job.

RENEWING WELDED TUBES

In some boilers of recent design, the superheater tubes and the economizer tubes are welded after they have been expanded. The renewal of these tubes is more complicated than the renewal of ordinary tubes. Procedures for renewing welding tubes are given in the appropriate manufacturer's technical manual.

PLUGGING BOILER TUBES

As an emergency measure, it is sometimes necessary to plug defective boiler tubes until they can be replaced.

CAUTION

Any tube that is plugged must have a hole drilled in it to prevent pressure buildup in the tube when the boiler is steamed.

Various sizes of tube plugs are carried in the supply system. The plugs are tapered to the required shape and are usually drilled and threaded at the larger end, so they may be removed with a tube plug extractor.

Tubes must be plugged at each end. Before driving a tube plug into position, be sure the plug and the inside of the tube are absolutely clean, so the plug makes good metal-to-metal contact with the tube. Drive the plug far enough in to ensure it will hold, but do not drive it so far in that it damages the tube sheet.

In plugging superheater tubes, use an offset driver to drive in the plugs when the tube holes do not fall in line with the handhole opening. When a superheater tube is plugged, it will eventually burn away after a period of service. When tubes have burned away (or when they have been removed) so much that they leave a gas lane more than three tube rows wide through the entire superheater tube bank, plug the gas lane with a

plastic or castable refractory. If the lane cannot be plugged, the firing rate of the boiler must be restricted to avoid overheating the superheater tubes next to the gas lane.

When a sidewall tube needs to be plugged, cut the tube 3 to 4 inches above the sidewall heater and 3 to 4 inches below the steam drum. The space left exposed after removal of the tube should be packed with plastic refractory to protect the pressure parts previously cooled by the plugged tube. Do not plug more than two tubes next to each other, since an exposed area wider than this cannot be effectively protected for an extended operation. Sidewall tubes that have been plugged should be replaced at the earliest opportunity.

When a rear wall tube needs to be plugged, cut the tube 3 to 4 inches from the headers or at other cutoff points specified in the manufacturer's technical manual. Use a plastic refractory to plug casing openings, to cover exposed areas not protected by firebrick or high-temperature castable refractory, and to cover the exposed pressure parts previously cooled by the plugged tube. Rear wall tubes that have been plugged should be replaced at the earliest opportunity.

Superheater screen 1 1/2 and 2 inches in outside diameter should, in general, be replaced, rather than plugged, when tube failure occurs.

In plugging generating tubes 1 inch and 1 1/4 inches in outside diameter behind the superheater tube bank (in single-furnace boilers) and behind the 2-inch tubes (in double-furnace boilers), consider gas laning and drum protection. Any complete lane through the tube bank more than three tube rows wide should be retubed, especially if such a lane is bounded by the boiler casing. Any drum area greater than 4 inches square should have refractory protection over the drum or, if this is not practicable, have blind nipples replace the failed tubes instead of just plugging the failed tubes. The blind nipples give greater protection to the drum than plugged tubes.

If an economizer element develops a leak, the ends of the element should be plugged at the inlet header and at the outlet header. To install a tapered plug in an economizer element, screw the plug extractor into the plug and insert the plug into the tube. Unscrew and remove the extractor from the plug. Drive the plug securely into position by holding one end of a piece of pipe against the plug and striking the pipe on the other end.

Figure 2-14 shows how to remove a plug from an economizer element. Screw the plug extractor into the plug. Place the handhole plate binder in position over the extractor, and then thread on the handhole fitting nut. As you tighten the handhole fitting nut, the plug pulls out.

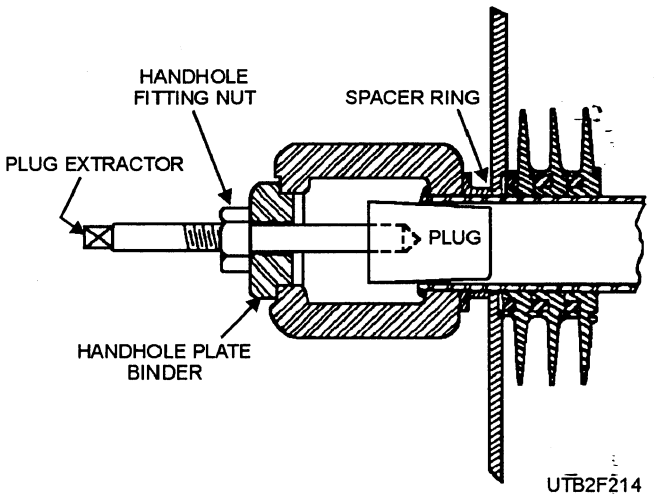

Figure 2-14.—Removing plug from economizer element.

Some activities, using boilers of recent design, are furnished with expandable gasketed plugs for plugging economizer elements. One of these plugs is shown in figure 2-15. The installation of the expandable plug is shown in figure 2-16. After inserting the plug assembly into the tube, hold a screwdriver in the slot of the retainer stem to keep the

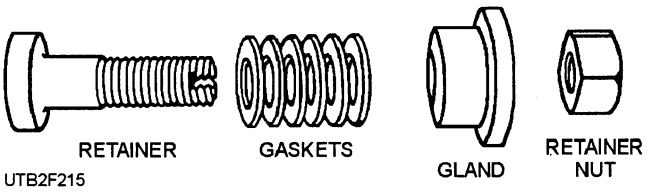

Figure 2-15.—Expandable gasketed plug for economizer element.

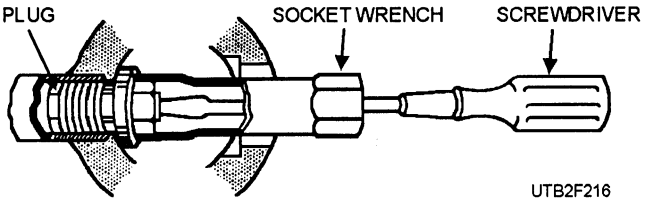

Figure 2-16.—Installing expandable plug in economizer element.

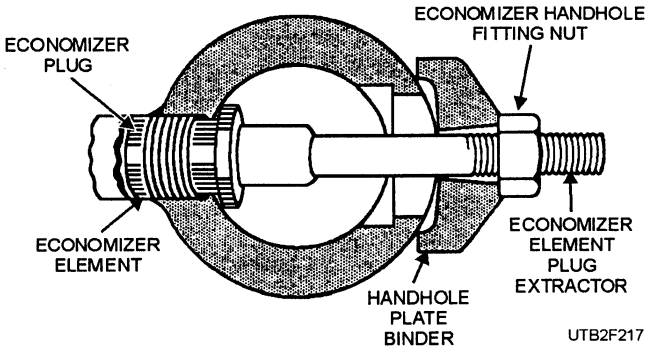

Figure 2-17.—Removing expand able plug from economizer element.

plug from turning, as you tighten the nut. As you tighten the nut using an open-end wrench or a socket wrench, the gaskets expand radially, as they are compressed axially.

The removal of an expandable plug is shown in figure 2-17. Insert a socket wrench or an open-end wrench through the handhole and remove the retainer nut. Insert the economizer plug extractor and then thread it onto the retainer. Place the handhole plate binder in position over the extractor and the thread on the handhole fitting nut. As you tighten the nut, the plug pulls out.

Q5. What five items of information are generally required on boiler tubes?

Q6. When tubes on a boiler drum or header made of 4-6 choromium steel are removed what method of removal cannot be used?

Q7. When tubes are fitted, tubes up to 2-inch-outside diameter should project how far into the drum or header?

Q8. Tubes 2 inches or larger should be belled between what size range?

Q9. What should you do to a plugged boiler tube to avoid pressure buildup in the tube when the boiler is operating?

REPAIRING BOILER REFRACTORIES

Learning Objective: Recognize maintenance and repair procedures for boiler refractories.

Furnaces are built with high-grade, fire-resistant materials that take a lot of punishment. Sooner or later, however, repairs become necessary. Furnace walls or floor may need repairing. The procedure for this repair is as follows:

First, mix the mortar, using a Navy-recommended fire clay or fire cement and fresh water. Do not add anything else. Make the mortar rather thin and without lumps.

Inspect the bricks for flaws and evenness. Choose the best edge for the furnace side. Dip the brick in fresh water and allow the excess water to drip off.

Now, dip one end and side of the brick into the mortar, using an edgewise motion to prevent air bubbles from forming. Lift the brick from the mortar and allow the excess mortar to drip off. Do not place any mortar on the wall or brick with a trowel.-The mortar sticking to the brick is all that is used.

If the mortar is too thick, you will not get the thin joints that you want. The mortar should be a little thinner than the usual wall plaster. You can feel the proper thickness with your hand. Some mortar will stick to your hand, as you lift it away from the mortar. Add more clay or water as necessary, and stir the batch often to keep the mortar at the desired consistency.

Place the brick quickly in position in the wall and pound it in place with a wooden mallet until no mortar can be forced out of the joints. With high-grade brick, joints can be made less than one thirty-second of an inch thick. Joints should never exceed one-sixteenth of an inch.

With a small trowel, fill in any unevenness in the furnace side of the seam and bead over the joints, as shown in figure 2-18. Be sure that no edges of the brick are exposed. The wall should be laid up evenly and smoothly. Any excess mortar that protrudes from the joints should be smoothed off with a small trowel, so the corners of the brick are protected.

Allow the wall to dry for about 12 hours with the burner shutters open to allow circulation of air, which permits the escape of some of the water added to the mortar. As soon thereafter as practicable, light the burner under the boiler and slowly bring the furnace up to operating temperature to bond the mortar to the adjacent brickwork.

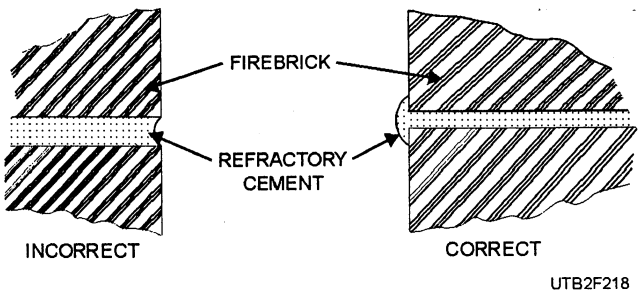

Figure 2-18.—Cementing brick.

When inspecting the boiler, you may find cracks or holes in the furnace lining. To make necessary repairs, mix some of the fire clay you used for brick mortar into a thick mixture. Use more mortar than you used for the brick mortar mix. Use a trowel to apply this wash.

While standard firebrick generally is used for normal refractory work, plastic firebrick is recommended for emergency patches and for building up furnace openings. Plastic firebrick is unfired firebrick in a stiff plastic condition. It offers a particular advantage in that, because of its plastic nature, it can be pounded into places where otherwise a firebrick of special shape would be required. The fusion point of plastic firebrick is practically equal to that of standard firebrick. Because of the moisture in the plastic material, however, a greater degree of shrinkage takes place. This factor prevents its general use for sidewalls. It provides an excellent material, though, for repairing brickwork, topping off side and back walls, repairing and constructing the burner openings and, general, for any part of the furnace not exposed to temperatures in excess of 2000°F. It is particularly adapted for use in place of specially formed brick of complicated shapes.

Plastic firebrick material, as received from the factory, ordinarily contains enough moisture for working. Avoid the addition of water or any foreign material. In laying up, chunks of plastic just as taken from the can should be rammed tightly into place (preferably in horizontal layers). In general, the more solidly the section of plastic is rammed up, the better it will be.

As the next step, the plastic section should be vented with 3/16-inch holes. Ensure that the holes extend clear through the plastic and are not more than 2 inches apart. This positioning allows deeper heat penetration during the baking-out process. It also permits ready escape of the steam formed from the moisture in the plastic. Do NOT trowel the surface of a new plastic section. This tends to prevent the escape of steam during baking out.

The plastic section should be held in place with as many anchor bolts as would have been provided had standard firebrick been used instead of plastic. The plastic section should be air-dried. This takes from 48 to 72 hours, depending upon the atmosphere. As soon as practicable after air drying, the furnace should be fired with a small fire and gradually brought up to operating temperature to complete baking out. Plastic requires a temperature of about 2900°F to 3000°F for baking out. If small shrinkage cracks open up, they should be filled with fire clay. If large cracks occur, they should be filled with plastic.

When used for patches, as in the case of brick falling out, the hole should be cleaned out to give at least 4 inches of body thickness to the plastic brick. In building up furnace openings, the use of a metal form is desirable. However, it is not absolutely necessary if care is exercised in making openings of the proper shape and concentric with the atomizer at every point. If furnace openings, as built, have a smooth surface, they should be roughened with a stiff wire brush before baking out.

The following ways to maintain newer boilers are recommended. The boiler is normally shipped with a completely installed refractory. This consists of the rear head (fig. 2-19), the inner door, and the furnace liner (fig. 2-20). Follow the instructions in the manufacturer's manual for the boiler you are maintaining. Where specific directions or requirements are furnished, follow them.

Normal maintenance requires little time and expense and prolongs the operating life of the refractory. Preventive maintenance through periodic inspection keeps the operator informed of the condition of the refractory and helps guard against unexpected downtime and major repairs.

Frequent wash coating of refractory surfaces is recommended. A high-temperature bonding air-dry type of mortar diluted with water to the consistency of light cream is used for this purpose. Recoating intervals vary with operating loads and are best determined by the operator when the heads are opened for inspection.

Maintenance consists of occasional wash coating of the entire liner. Face all joints or cracks by applying high-temperature bonding mortar with a trowel or use your fingertips. This should be done as soon as the cracks are detected. Should segments of the liner become burned out or broken, replace the entire refractory. Any refractory that may break out should be removed as soon as detected, so it will not fuse to the bottom of the furnace and obstruct the burner flame.

Remove the existing refractory and thoroughly clean that portion of the furnace covered by the liner to remove all old refractory cement or other foreign material to ensure the new liner seats firmly to the steel. Inspect all furnace metal for soundness. There may be metal clips welded in the furnace at the extreme end of the liner. These clips were installed to prevent shifting during original shipment and serve no other

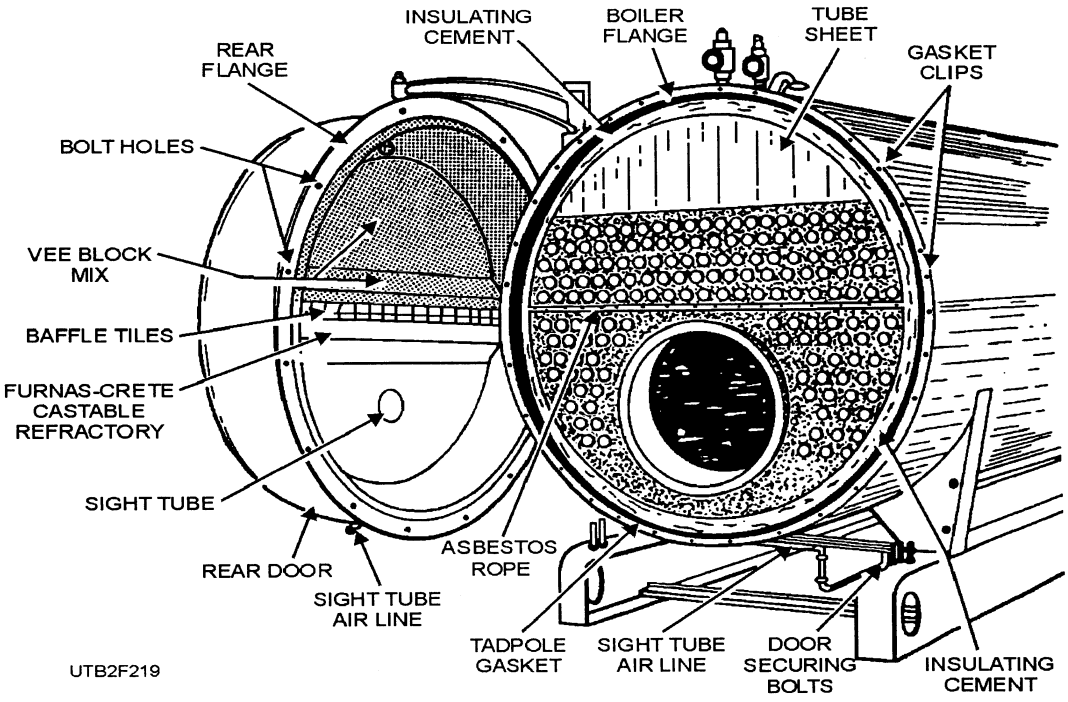

Figure 2-19.—Rear door open.

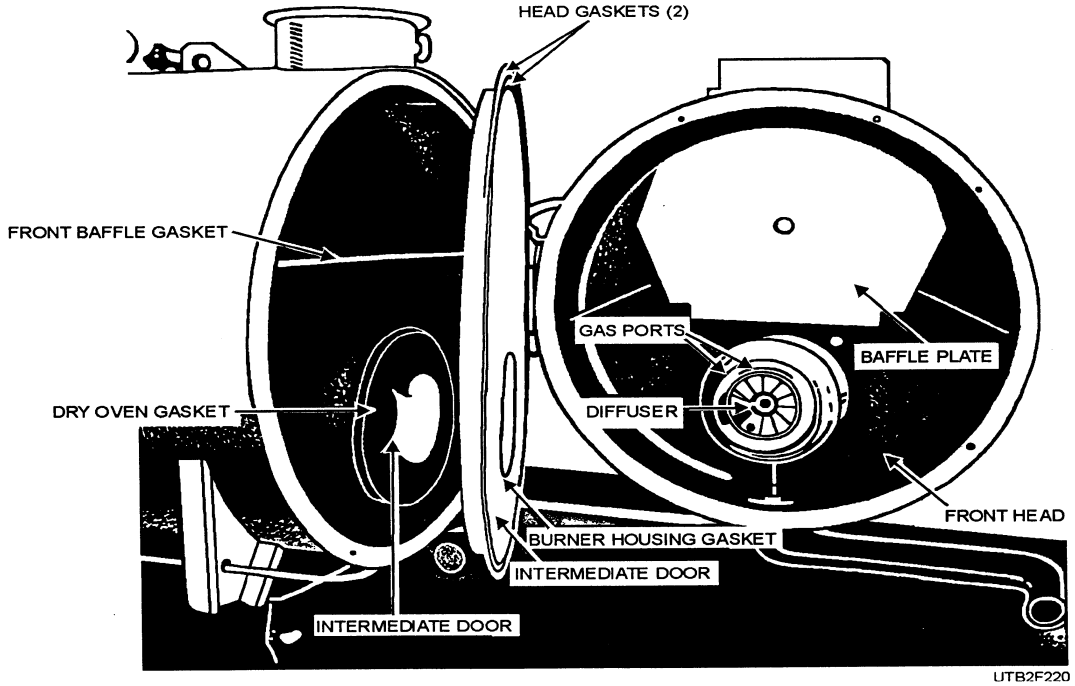

Figure 2-20.—Front head open-gas-fired CB 125-150-200.

purpose. They are tack-welded in place and can be removed when you are installing the new liner. If they are not removed, make sure the liner has clearance between this clip and the end of the refractory to allow for expansion in this direction.

Depending upon the design pressure of the boiler, the furnace may be of the corrugated type. Although it is not necessary to fill in the depressions for convenience of installation, some or all of the corrugation valleys may be filled with insulating cement. The liner tile should be fitted tightly against the crown of the corrugations.

The furnace extension of the boiler or a dry oven is shown in figure 2-21. The throat tile should be installed flush with the front of the oven and should fit tightly against its sides. The two rows of furnace tile should be fitted tightly against the furnace wall. It is not necessary to allow for expansion.

It is recommended that the tile be dry fitted, match marked, removed, and then reinstalled with the proper amount of refractory cement. Thin joints are desirable. Generally, it is necessary to shave a portion from one or more tiles to obtain a fit. If a fill piece is required, cut it to fit and install this piece at the bottom of the furnace. It is important to have a good seal between-the burner housing and the throat tile. Liberally coat-the sealing area with an insulating pulp cement or equivalent mixed with water before swinging the burner housing into place.

The rear door is a steel shell containing horizontal baffle tiles and lined with insulation material and a castable refractory (fig. 2-19).

Burned or discolored paint on the outer surface of the door does not necessarily indicate refractory trouble but may be an indication of other conditions such as the following:

- Leaking gaskets.
- Improper seal.
- Door retaining bolts insufficiently or unevenly tightened.
- Air line to the rear sight tube is blocked or loose.

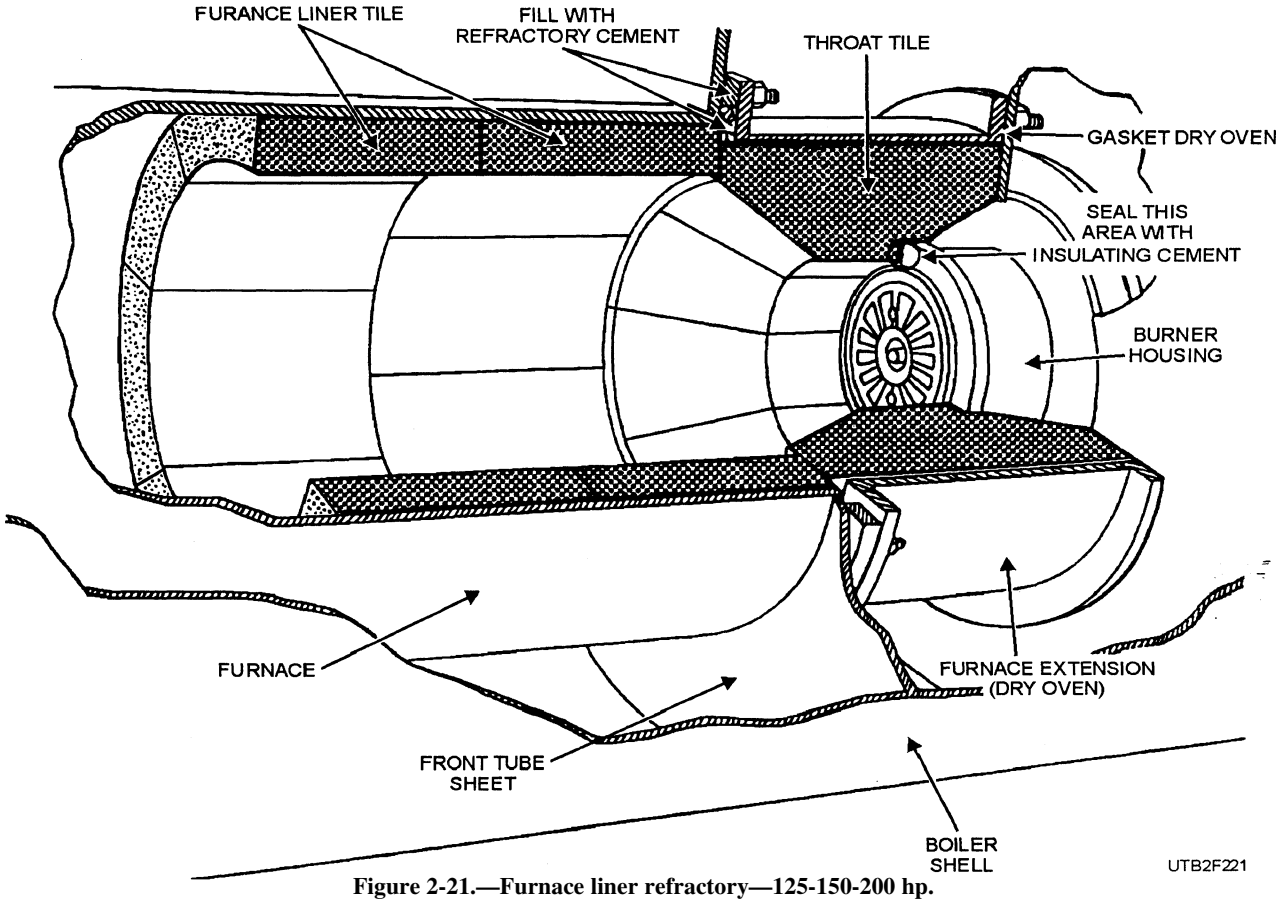

Figure 2-21.—Furnace liner refractory—125-150-200 hp.

- Repainted with other than heat-resistant paint.

Therefore, before you assume the refractory requires re-working. check the following:

- Condition of the tadpole gasket.
- The condition of the insulating cement protecting the tadpole gasket.
- Horizontal baffle tile for large cracks, breaks, chipped corners, and so forth.
- Cracks in the castable refractory at the ends of the baffle tile.
- Tightness of door bolts.
- Air line to the sight tube to ensure it is clear and all connections are tight. If necessary, blow it clear with an air hose.

It is normal for refractories exposed to hot gases to develop thin "hairline" cracks. This by no means indicates improper design or workmanship. Since refractory materials expand and contract to some degree with changes in temperature, they should be expected to show minor cracks because of contraction when examined at low temperature. Cracks up to approximately one-eighth of an inch across may be expected to close at high temperature. If there are any cracks that are relatively large (1/8-inch to 1/4-inch width), clean and fill them with high-temperature bonding mortar. Any gap that shows between the castable refractory and the baffle tile should be filled-in in a similar fashion.

After opening the rear door, clean off the flange surface of the door with a scraper or wire brush. Clean the surface of the refractory carefully with a fiber brush to avoid damaging the surface. Clean the mating surfaces of the baffle tile and the boiler shell. Remove all dried-out sealing material. Wash-coat the lower half of the rear door refractory before closing it. The upper half of the door contains a lightweight insulating material similar to that used in the inner door. A thin washcoat mixture applied gently with a brush is helpful in maintaining a hard surface.

The front inner door is lined with a lightweight castable insulation material. Thin "hairline" cracks may develop after a period of time; however, these cracks generally tend to close because of expansion when the boiler is fired. Here, again, a thin washcoat mixture is helpful in maintaining a hard surface. Minor repairs can be accomplished by enlarging or cutting out affected areas, making certain they are clean, and then patching as required.

Should the entire installation require replacement, remove existing material and clean to the bare metal. Inspect the retaining pins and replace if necessary. Reinforcing wire suitably attached may also be used. The recommended insulation is known as Vee Block Mix and is available in 50-pound bags. Mix the material with water to a troweling consistency. Mixing should be completely uniform with no portion either wetter or drier than another. Trowel this mixture into any areas that are being patched. If replacing complete insulation, begin at the bottom of the door and apply the mixture to a thickness equal to the protecting shroud. With a trowel, apply the mixture horizontally back and forth across the door in layers until the required thickness is reached. Allow the mixture to air-dry as long as possible. If immediate use of the boiler is required, fire as slowly as possible to avoid rapid drying of the material.

Whenever the front or rear door is opened for inspection, the head gasket should be checked for hardening and brittleness. Doubtful gaskets should be replaced. Coat the gasket with an oil and graphite mixture before closing the door. Make certain all gaskets retaining rivets are in place. The flange of the door should be clean and free of any hardened cement, scale, and so forth. Check the condition of the rope gasket used as a baffle seal. Replace if necessary. If the rope is in good condition, liberally coat it with an insulating pulp before closing. Make sure the rope is properly positioned.

If it is necessary to replace the rope, wire brush the tube sheet area to remove all of the old sealing material. Place a new piece of 1 1/2-inch-diameter rope gasket on the lip of the baffle tile. Hold it in place with furnace cement or an adhesive.

NOTE

Earlier models have several steel bar segments tack-welded across the tube sheet to serve as a gasket retainer for 5/8-inch-diameter rope. It is suggested that these bars are removed and 1 1/2-inch-diameter rope be used.

Generously apply a seal, consisting of a pulp mixture of insulating cement and water, around the entire rear door circumference. Place the pulp around the inside diameter of the head gasket, as shown in figure 2-16. Also coat the tube sheet area adjacent to the baffle tile. When the door is closed, the pulp compresses to protect the tadpole gasket and to form a

seal between the refractory surface and the tube sheet. The insulating pulp seal is not needed or used on the front head. Make sure the gaskets are in position when closing.

When you are closing the door, bolts should be snug and tightened evenly to avoid cocking the door and damaging the gasket. Start tightening at the top center bolt and alternate between the top center bolt and the bottom center bolt until both are drawn-up tight. Do not overtighten. Continue the tightening sequence along top and bottom, tightening the bolts alternately until the door is secured and gas-tight. After the boiler is back in operation, retighten the bolts to compensate for any expansion.

NOTE

Proper sealing of the doors is essential to avoid leakage of combustion gases and loss of heat and operating efficiency.

Q10. When plastic firebrick is used, troweling the new section of refactory will cause what condition to occur during the baking-out process?

Q11. What temperatures are required to bake out plastic firebrick?

Q12. Leakage of combustion gases, loss of heat, and loss of operating efficiency can be caused by what condition?

BOILER OPERATIONS

Learning Objective: Recognize different boiler checks, start-up, securing procedures, and boiler emergencies. Understand the purpose and types of data in boiler operating logs.

The operation of a boiler consists of seven major phases: (1) prewatch assumption checks, (2) preoperating checks, (3) lining up systems, (4) operating procedures, (5) operating checks, (6) securing procedures, and (7) boiler emergencies.

PREWATCH ASSUMPTION CHECKS

The prewatch assumption checks are often neglected by boiler watch standers. Before you assume the responsibility of a boiler watch stander, you must complete specified checking procedures to ensure that the equipment in service is in sound operating condition and is functioning satisfactorily. When the watch is relieved, the watch stander coming on duty inspects the instrument readings and charts, visually inspects all equipment, and exchanges information with offgoing watch standers. Oncoming watch standers should complete the following inspections and tests before assuming duty:

- Visually inspect the setting and casting.
- Observe the furnace and firing conditions.
- Inspect the charts, logs, controls, and so forth, on equipment performance during previous watch.
- Inspect the fans, dampers, damper drives, and other driven auxiliaries.
- Test the water columns and gauge glasses.
- Obtain information from the watch standers on duty on the boiler operating condition and any unusual event or trouble that occurred during the previous watch.

Immediately after accepting the operational responsibility, you should make a complete inspection of all auxiliary equipment as follows:

- Inspect all electric motor drives for abnormal temperature, condition of bearings, and so forth.
- Inspect the fan and pump bearings for overheating and adequacy of lubrication.
- Visually inspect the boiler and all associated equipment, listen for unusual sounds, friction, vibration, and other abnormal conditions.
- Inspect the burners, fuel supply, pilot systems, and other fuel supply components.
- Review the log sheets to obtain information on past operating conditions and unusual events.

REOPERATING CHECKS

The preoperating checks should be completed before lining up and lighting off a boiler. These checks are performed to ensure that the plant and associated equipment are in a safe and efficient operable condition. The major preoperating procedures applicable to boilers in general, as well as additional procedures for gas-fired and oil-fired boilers are shown in tables B, C, and D, appendix II.

LINING UP SYSTEMS

After you have completed the preoperating checks, your next job is to line up the boiler systems. The procedure used in lining up boiler systems (fuel,

water, steam, and electrical) vary with different types and kinds of boil ers. Always follow the manufacturer's instructions for the boiler being used. Before lining up a boiler, complete the following basic tasks:

1. Fuel oil
   a. Measure with a stick or gauge.
   b. See that the proper valves are open.
   c. Remove any excess accumulation of water in the tank.
2. Gas
   a. Check the pressure.
   b. Check for leaks.
3. Gas-fired unit
   a. Check and regulate the water level and line up the feed system.
   b. Examine the burner, control valves, and safety shutouts for proper working condition before lighting off.
   c. Purge air out of the gas lines by external vents before lighting off.
   d. Check the draft devices and purge the combustion chamber.
   e. Light the pilot and set the flame.
   f. Open the main gas cock.
   g. Close the burner controls switches to light the burner.
   h. Maintain the fuel-air ratio for complete combustion.
4. Oil-fired unit
   a. Check and regulate the water level. Line up the feedwater system. Check the operation of the feed pump.
   b. Line up the fuel oil system.
   c. Purge the combustion chamber.
   d. Close the burner control switch; if automatic, the burner should light off.
   e. Should ignition fail, the furnace must be purged before a second attempt is made.
   f. Do not allow oil to impinge on brickwork or part of the boiler.
   g. Maintain the proper air-fuel ratio.

In general, the basic lighting off procedures for most boilers are as follows:

1. Close the following valves:
   a. All blowdown valves and boiler drains.
   b. Chemical feed valves.
   c. Boiler nonreturn.
   d. Main steam stops.
   e. Soot blower header (steam system) and all soot blowers.
   f. All burner fuel valves.
   g. Water column and feedwater regulator drains.
   h. Auxiliary valves, as necessary.
2. Open the following valves:
   a. Vent valves on boiler drums and superheaters.
   b. Superheater drain valves.
   C. Recirculating line valves in economizer, if so fitted.
   d. Feedwater stop and check.
   e. Drum steam gauge connection.
   f. Water column gauge connections.
   g. Water column gauge glass valves.
   h. Auxiliary valves, as necessary.
3. Start filling the boiler with properly treated water at a temperature close to the temperature of the pressure parts. The temperature difference should not be greater than 50°F to avoid severe temperature stresses. Fill the boiler to level just below the middle of the glass on the water column.
4. Close the induced draft fan dampers (or other flue gas control dampers).
5. Start the induced draft fan.
6. Close the forced draft fan dampers (or other air control dampers).
7. Start the forced draft fan.
8. Start the air heater rotor, if a regenerative type of air heater is installed.
9. Light off the boiler under the manufacturer’s instructions and maintain a firing rate so the water temperature in the boiler is raised 100°F per hour until operating pressure is reached. On

new boilers, expansion movement should be checked to see that no binding or interference occurs.

10. When burning oil, prevent incomplete combustion in the furnace: Unburned oil is deposited on the cooler surfaces in the back of the unit, such as the economizer and air heater, and this creates a potentially dangerous condition.
11. When the steam drum reaches about 25 psig, close the vent valves on the boiler drum. Check the steam pressure gauge now to be sure that it is registering.
12. Ease up on the stem of the main steam stop valve to prevent any serious expansion stresses. If there is no steam on either side of the main steam stop valve, gently lift and reseat it to make sure that it is not stuck. Open the drain valve on the boiler side of the main stop valve.
13. Observe the water level carefully to ensure that no water is carried over into the superheater. Maintain a normal water level in the drum by blowing down or feeding water as may be required.
14. Operate the vent and drain valves in the superheater headers and economizer by following the manufacturer's instructions. In general, drain valves in the superheater inlet header are closed first, followed by the drains in the superheater outlet header. In any case, the superheater outlet header drain and vent valves must not be completely closed until enough steam flow through the boiler outlet valve is assured.
15. Check for leaking gasket joints. If a leaking gasket is discovered, shut down the boiler and tighten the joints.
16. If the gasket still leaks, drop the pressure again, replace the gasket, and repeat the lighting off sequence.

Before cutting in the boiler, proceed as follows:

1. Open all drain valves between the boiler and the header, especially the drains between the boiler and the two stop valves.
2. Warm up the steam line between the boiler and the header by backfeed through the drip line or by means of the bypass valve.
3. When the steam line is thoroughly heated and at header pressure, open the bypass valve.
4. When the boiler pressure almost reaches line pressure, open the bypass line around the main steam stop valve to equalize pressures and temperatures in the piping; then slowly open the main steam stop valve. As the boiler reaches line pressure and is actually steaming, slowly raise the nonreturn valve stem to the full open position.
5. After the boiler is on line, close all superheater drains.
6. Inspect the entire boiler, and close any drain valves that are not discharging condensate.
7. Close the economizer-recirculating valve when an adequate continuous feedwater flow is established.
8. Close the drain valve at the nonreturn valve.
9. Close the bypass valve around the nonreturn valve.
10. A boiler with a pendant (nondrainable) superheater has a slightly different operation. Superheaters of this type trap condensate in the loops that must be boiled off before the firing rate can be increased and the steam flow started.
11. Maintain a constant firing rate. The strength of thick steam drums may be impaired by excessive temperature differentials between the top and the bottom of the drum, if the proper firing rate is not maintained. Tubes may start leaking at rolled seats and the superheater tubes may overheat.
12. On boilers generating saturated steam, follow the above instructions for removing air and condensate.

OPERATING PROCEDURES

Success in operating boilers depends largely upon the operator's performance. No fixed set of rules can be established to fit all conditions. Consequently, the operator must see and interpret all prevailing operating conditions and, if necessary, take action to control, modify, or correct them. To be able to do this, the operator must be thoroughly familiar with the characteristics and standard operating procedures for the boiler for which the operator is responsible. This section acquaints you with some of the basic operating procedures that generally apply to most, if not all,

boilers you will be assigned to operate. For specific operating instructions, consult the manufacturer's manual for the boiler concerned.

Normal Operation

During normal operation of boilers, the operators have two major responsibilities. First is to maintain proper water level at all times. If the water level is too low, tubes may overheat, blister, and rupture. If water level is too high, carry-over of water to the superheater tubes may damage the superheater elements and the turbine. The second is to prevent loss of ignition when burning fuel is in suspension. Maintain safe and efficient combustion conditions in the furnace and correct fuel-air ratios.

Blowdown

Establish definite intervals for blowing down the boiler, depending on the type of operation and chemical analysis of the boiler water. During regular operation, never blow down economizers or water-cooled furnace walls. Blowdown valves on this type of equipment serve only as drain valves.

Blowdown should be at reduced or moderate rates of steam for low point drains or blowdown valves. When the water glass is not in full view of the operator blowing down a boiler, another operator should be temporarily assigned to observe the water glass and signal the operator handing the valves. For control of water conditions when working, use continuous blowdown to maintain the proper concentration at all times and to prevent blowing down large quantities of water while the boiler is operating at a high capacity.

Boiler Makeup Water

Use only properly treated water for makeup, and maintain the boiler water conditions as specified in water treatment instructions. Make an accurate water analysis at specified intervals. Carefully control the blowdown and the addition of treatment chemicals to meet the manufacturer's specifications.

Soot Removal

Remove soot from hoppers and pits at definitely established intervals, as necessary.

Instrument Readings

Establish definite intervals for observing and recording the readings on all important instruments and controls. Be sure you obtain accurate readings-and see that the readings are recorded properly on the log sheet or other required record.

OPERATING CHECKS

To help ensure efficient operation of the boiler, operators should ensure that proper operating checks are done during boiler operations. Operating checks, as shown in table E, appendix II, apply to most, if not all boilers.

Keys to efficient boiler operation and performance are as follows:

1. Flue-gas temperature
   a. Keep the temperature low.
   b. Temperature should be about 150 degrees higher than temperature of steam produced.
2. Flue-gas analysis
   a. Take periodically.
   b. Maintain proper CO;! level for fuel used.
3. Flame
   a. Should be long and lazy.
   b. Must not enter the tubes.
   c. Not dark and smoky.
   d. Have a light brown haze from stack, except gas.
   e. When the fuel is oil, have a yellow flame with dark or almost smoky tips.
4. Draft
   a. Usually 0.03-0.06 inch of water.
   b. Check the manufacturer‘s recommendations.
5. Makeup feed
   a. Maintain low rate.
   b. Avoid excessive boiler blowdown.
6. Insulation
   a. Ensure boiler and lines are well insulated.
7. Water treatment
   a. Carry out prescribed treatment of boiler water.

SECURING PROCEDURES

The recommended procedures for securing boilers are as follows:

1. Reduce the load on the boiler slowly, cutting out the fuel supply by proper operation of the fuel-burning equipment.
2. Maintain normal water level.
3. When the boiler load is reduced to about 20% of rating, change the combustion control and the feedwater control to manual operation.
4. Before securing the final fuel burner, open the drain valves at the steam and nonreturn valve and the drain valve on the superheater outlet header. Be sure the bypass valve around the nonreturn valve is closed.
5. Secure the final fuel burner when the load has been reduced sufficiently.
6. Continue operating the draft fans until the boiler and the furnace have been completely purged.
7. Shut down the draft fans.
8. Close the dampers, including the air heater and superheater bypass dampers, when provided.
9. Follow the manufacturer's instructions for the rate of cooling the boiler. A thermal strain may occur if the change is too fast.
10. When the boiler pressure has started to drop, close the steam stop and nonreturn valve.
11. When the boiler no longer requires any feed and the nonreturn valve is closed, open the valve in the recirculating connection of the economizer, if provided.
12. Let the boiler pressure drop by relieving steam through the superheater drain valve and the drain valve at the nonreturn valve. If the boiler is losing pressure at a rate faster than specified by the manufacturer, throttle the drain valves as necessary to get the proper rate. Do not close the valves completely.
13. When the drum pressure drops to 25 psig, open the drum vent valves.
14. If a regenerative type of air heater is used, the rotor may be stopped when the boiler exit gas temperature is reduced to 200°F.
15. The boiler can be emptied when the temperature of the boiler is below 200°F. Before sending someone into any part of the boiler, close and properly tag all controls, valves, and drains or blowdown valves connected with similar parts of other units under pressure at the time. This move prevents any steam or hot water from entering the unit. The tags are to be removed only by the authorized person who tagged out the boiler and must remain in place until the work is completed. Ventilate the boiler thoroughly and station a person outside. Inside, use only low voltage portable lamps provided with suitable insulation and guards. Even 110 volts can kill under the conduction conditions inside a boiler. All portable electrical equipment should be grounded; and electric extension cords should be well insulated, designed to withstand rough usage, and maintained in good condition.

BOILER EMERGENCIES

Typical emergency situations encountered with the operation of boilers are (1) low water, (2) high water, (3) serious tube failure making it impossible to maintain water level, (4) flarebacks caused by an explosion in the combustion chamber, (5) minor tube failure indicated by trouble in maintaining water level under normal steam demand, and (6) broken gauge glass on the water column. Table F, appendix II, lists the safe procedures to follow when these boiler emergencies occur.

BOILER OPERATING LOGS

The main purpose of boiler operating logs is to record continuous data on boiler plant performance. Logs become a source of information for analyzing the operation of the boiler for maintenance and repair. The daily operating log sheets provide the basic information around which maintenance programs are developed. The log is arranged for use over a 24-hour period divided into three 8-hour shifts. Log sheets vary among different activities, but you should have no difficulty in making log entries once you understand what information is required. The types of information to be entered in the appropriate column of the log are as follows:

- Steam pressure. Based on steam gauge readings and indicates the performance of the boiler.
- Steam flow. Actual output of the plant, in pounds per hour, to obtain steam flow. The data from these entries are used to determine the number of boilers to operate for greatest efficiency.

- Feedwater heater pressure. Indicates whether the proper deaerating temperature can be maintained in the heater.

- Feedwater heater temperature. Shows the effectiveness of the feedwater heater. A drop in steam-supply pressure or insufficient venting may cause low heater temperature.

- Feed pump pressure. Indicates the effectiveness of the boiler feed pumps. If the feedwater supply fails, the pressure reading enables the operator to determine whether the trouble is in the feed pumps. Pumps are defective when the feed pump pressure reading is below normal.

- Last-pass draft. Indicates the actual draft produced by the stack or the induced-draft fan. A decrease in the last-pass draft with other conditions constant indicates leaking baffles. An increase shows gas passages are becoming clogged.

- Percent CO_2 flue gas. This value is a measure of relative quantities of air supplied with fuel. It is kept at a value that has been established as most satisfactory for the plant, fuel, firing rate, and other related factors. In plants not equipped with CO_2 recording meters, this value is determined with a hand gas analyzer.

- Flue gas temperature. Shows the quantity of heat leaving the boiler with flue gases. This heat represents a direct energy loss in fuel. Dirty heating surfaces or leakage of baffles causes high flue gas temperatures. Excessive fouling of firesides of boilers increases draft loss, while leaking baffles decrease draft loss. Either condition raises the temperature of flue gas above normal.

- Fuel. Fuel oil quantities are determined by the use of a measuring stick and tables supplied with a given tank. Some tanks are equipped with gauges to show the fuel volume. Always determine the quantity of fuel used, as this represents a major operating cost.

- Outside temperature. The load on a heating plant is greatly influenced by outside temperature. Record this temperature for comparison with steam generated and fuel used. These comparative values are useful in finding abnormal fuel consumption and in estimating future requirements.

- Makeup water. Record the quantity of makeup water used to enable the operator to note an abnormal increase before a dangerous condition develops. Return all possible condensate to the boiler plant to save water and chemicals used to treat water.

- Water pressure. Indicates whether water is sufficient.

- Hot-water supply temperature. Insufficiently heated water can cause scaling or deposits in a boiler.

- Water softeners. Where softeners are used, a decrease in the quantity of time used for runs between regeneration indicates either an increase in hardness of incoming water or a deterioration of softening material.

- Total and average. Space is provided for recording the total and average quantities per shift.

- Steam flowmeter. The steam flowmeter integrator reading at the end of a shift and multiplied by the meter constant gives the quantity of steam generated. Dividing steam generated by fuel burned (gallons of oil) yields a quantity that shows the economy obtained. If a plant does not have a steam flowmeter, pumps can be calibrated for flow and a record kept of their operating time or condensate and makeup water can be metered.

- Boiler feed pumps in service. Makes it possible to determine operating hours and to ensure that various pumps are used for equal lengths of service.

- Phosphate, caustic soda, and tannin added. Is valuable in keeping the correct boiler water analysis and in determining total chemicals used.

- Remarks. The Remarks column is used to record various types of information for which space is not provided elsewhere on the log sheet. Note irregularities that are found during inspections, dates boilers are drained and washed out, equipment to be checked daily, and so forth.

- Other personnel. Names of personnel responsible for specific tasks and data must be entered on the log sheet, if required.

Q13. Why are prewatch assumption checks performed?

Q14. What is the next step after completing preoperating checks?

Q15. What is the first step to be taken when cutting in the boiler?

Q16. What are the two major responsibilities of boiler operators during normal boiler operations?

Q17. Flu-gas temperatures should be at how many degrees above steam production temperature during boiler operations?

Q18. When securing a boiler, at what pressure should you open the drum vent valves?

Q19. What is the purpose of a boiler operating log?

SAFETY

Learning Objective: Understand the relationship of safety in operating and maintaining boilers. Recognize the different types and use of lockout devices in boiler maintenance.

In servicing boilers, the need for SAFETY cannot be overemphasized. Much progress has been made over the years in the development of safety devices for boilers. There are still many ways, however, in which serious accidents can happen around boilers. A boiler operator or serviceman who is careless on the job threatens the safety of everyone. Accidents somehow have a way of happening at a moment we least expect. All the more reason, therefore, for constant alertness and close attention to detail. Do not take chances! BE SAFETY CONSCIOUS!

Some of the major safety precautions to be observed by Utilitiesmen engaged in boiler operation and servicing are presented below.

As protection against toxic or explosive gases, boiler settings must be ventilated completely and tested for toxic or explosive gases before crews are permitted to enter.

The covers of manholes must be removed for ventilation before people enter the drum.

Before anyone enters a steam drum, mud drum, or other waterside enclosure, steam and feed lines connected to the headers under pressure should be isolated by a stop valve and a blank with an open telltale valve in between, or by two stop valves with a telltale valve opened in between.

A ventilating fan should be operating in the drum when someone is working in the boiler.

Workers should not be inside the waterside of the boiler when pressure is being applied to test a valve that has not been under pressure.

Workers should wear protective clothing when making boiler water tests.

Boiler settings must be examined daily for external air leaks. Cracks, blisters, or other dangerous conditions in joints, tubes, seams, or blowoff connections are to be reported to your senior chief petty officer immediately.

Boilers should also be examined regularly for deposits on their heating surfaces and for grease or other foreign matter in the water. Boilers showing any such faults should be cleared at the first opportunity and should not be used until cleared.

Performing certain adjustments and repairs while pressure is up is prohibited. A complete absence of pressure is to be ensured by opening the air cock or test and water gauge cocks connecting with the steam space before fittings or parts subject to pressure are removed or tightened, and before manhole or handhole plate fittings are loosened on a boiler that has been under pressure.

Combustion control, feed control, and burner, stoker, or similar adjustments are permitted with the boiler steaming, since many adjustments can be made only when pressure is up.

When cleaning operations are performed, workers should wear the proper personal protective equipment. The following requirements apply:

- Hard hats and goggles must be worn.
- When a worker is chopping slag inside a furnace, a respirator must be worn.
- Safety-toed shoes or toe guards must be worn to prevent injuries from falling slag.
- When someone is working inside the furnace, a large warning sign, such as Caution-Man Working Inside, should be placed near the furnace entrance.
- The use of open-flame lights is prohibited in boilers. When cleaning where flammable vapors and gases may be present, workers are to use only explosionproof portable lamps equipped with heavily insulated three-wire conductors, with one conductor connecting the guard to ground.
- Oil accumulated on furnace bottoms should be cleaned out immediately.
- The fuel-oil suction and discharge strainers should be cleaned at least every 8 hours and more frequently if necessary.
- Condensate pits in boiler rooms should have metal covers. If the pits must be opened for maintenance, adequate guards should be placed around them and warning signs posted.

- Wear goggles with dark lenses, Number 1.5 to 3 shade, and suitable fireproof face shields when working near or looking through furnace doors of boilers in operation.

- When firing a cold boiler, be sure that the air vents are open on the boiler proper and that the drains are open on the superheater; keep these open until steam is liberated from the openings. Superheater vents must remain open until the boiler is on the line.

- Be sure gas-fired and oil-fired boilers, whether manual or automatic, are cleared of combustible gases after each false start.

All semiautomatic (multiburner) boilers and all fully automatic boilers should be equipped with a manually activated switch for pilot ignition and a control device to prove the pilot flame is on before the main fuel valve is opened. DO NOT USE A HAND TORCH TO LIGHT OFF A BOILER. If a hand torch is applied to a firebox filled with vaporized oil, a severe boiler explosion is likely to occur.

Prevent overheating of boilers equipped with superheaters by. firing at a slow rate during the warm-up period and by allowing a small amount of steam to flow through the superheater.

When taking over a watch, blow the water gauges and note the return of the water in the glass. Be certain of the water level at all times. Do NOT be misled by a dirt marking on the gauge that may look like the surface of the water. Do NOT depend entirely upon automatic alarm devices and automatic feedwater regulators.

If the water goes out of sight in the bottom of the gauge glass, kill the fire with the quickest means available; immediately close the steam stop valve, and allow the boiler to cool slowly; then, drain the boiler completely and open it for inspection. DO NOT FEED COLD WATER TO A BOILER THAT HAS HAD LOW WATER UNTIL THE BOILER HAS COOLED.

Check the water on steaming boilers by try cocks at least once each watch and before connecting a boiler to the line.

Check safety valves often to be sure they will pop at the correct pressure, as marked on the nameplate. Do NOT break the seal of a safety valve or change its adjustment, unless such action has been authorized. NEVER weight pop valves, relief valves, and so on, to increase the recommended steam pressure for which the boiler is approved.

Do not use oil from a tank in which a lot of water is mixed with oil unless a high suction connection is provided. When an atomizer sputters, shift the suction to the standby tank or another storage tank. A sputtering atomizer indicates water in the oil.

Reduce the fouling of oil heaters by using as few heaters as possible. Recirculate the oil through the used heaters for a short time after securing the burners. Maintain the prescribed fuel-oil temperature; do NOT exceed it.

If a large steam leak occurs in a boiler, shut off the burners, continue to feed water until the fire is out, close the steam stop valve, ease the safety valves, clear the furnace of gases, close the registers, and cool the boiler slowly.

Do NOT tighten a nut, bolt, or pipe thread, nor strike any part, nor attempt other adjustments to parts while the boiler is under steam or air pressure.

Take care to prevent lubricating oil, soap, or other foreign substances from getting into the boiler. Condensate from cleaning vats should be drained to waste and not returned to the boiler.

Close the furnace openings as soon as all fires have been put out and the furnace has been cleared of gases.

At shore installations, the handles on pull chains to boiler water-gauge cocks and water-gauge glass stop valves should be painted the following colors:

Opening water-gauge glass stop valves	WHITE
Closing water-gauge glass stop valves	RED
Top gauge cock	YELLOW
Center gauge cock	GREEN
Bottom gauge cock	BLUE

Do NOT use water to put out an oil fire in the furnace.

When fires are banked, make certain the draft is enough to carry off flammable gas accumulations.

The following lists contain a number of actions to which you should ALWAYS be alert and a number of actions you should NEVER perform.

SAFETY PRECAUTIONS

Always study every conceivable emergency and know exactly what action to take.

Always proceed to proper valves or switches rapidly but without confusion in time of emergency. You can think better walking than running.

Always check the water level in the gauge glass with the gauge cocks at least daily—also at any other time you doubt the accuracy of the glass indication.

Always accompany orders for important operations with a written memorandum. Use a logbook to record every important fact or unusual event.

Always have at least one gauge of water before lighting off. The gauge cocks should check the level.

Always be sure the blowdown valves are closed, and proper vents, water-column valves, and pressure-gauge cocks are open.

Always use the bypass if one is provided. Crack the valve from its seat slightly and await pressure equalization. Then open it slowly.

Always watch the steam gauge closely and be prepared to cut the boiler in, opening the stop valve only when the pressures are nearly equal.

Always lift the valve from its seat by the hand lever when the pressure reaches about three quarters of popping pressure.

Always consult the CEC officer in charge of the plant, your CPO, or other proper superior and accept his/her recommendations before increasing the safety-valve setting.

Never fail to anticipate emergencies. Do not wait until something happens before you start thinking.

Never start work on a new job without tracing every pipeline in the plant and learning the location and purpose of each and every valve regardless of size. Know your job!

Never leave an open blowdown valve unattended when a boiler is under pressure or has a fire in it. Play safe, your memory can fail.

Never give verbal orders for important operations or report such operations verbally with no record. Have something to back you up when needed.

Never light a fire under a boiler without checking all valves. Why take a chance?

Never open a valve under pressure quickly. The sudden change in pressure, or resulting water hammer, may cause piping failure.

Never cut a boiler in on the line unless its pressure is within a few pounds of header pressure. Sudden stressing of a boiler under pressure is dangerous.

Never bring a boiler up to pressure without trying the safety valve. A boiler with its safety valve stuck is the same as playing with dynamite.

Never increase the setting of a safety valve without authority. Serious accidents have occurred from failure to observe this rule.

In case of an oil fire in the boiler room, close the master fuel-oil valve and stop the oil pump.

Other than the above precautions, the following list contains a number of SAFE practices that you should try to follow in your work. It also contains a number of UNSAFE practices that you must avoid.

SAFE PRACTICES

Always have the valve fitted with a new spring and restamped by the manufacturer for changes over 10 percent.

Always keep out loiterers, and place plant operation in the hands of proper persons. A boiler room is not a safe place for a club meeting.

Always consult the CEC officer in charge of the plant, your CPO, or other proper superior before making any major repair to a boiler.

Always allow the draft to clear the furnace of gas and dust for several minutes. Change draft conditions slowly.

Always consult someone in authority. Two heads are better than one.

UNSAFE PRACTICES

Never change adjustment of a safety valve more than 10 percent. Proper operation depends on the proper spring.

Never allow unauthorized persons to tamper with steam plant equipment. If they don't injure themselves, they may injure you.

Never allow major repairs to a boiler without authorization.

Never attempt to light a burner without venting the furnace until clear. Burns are painful.

Never fail to report unusual behavior of a boiler or other equipment. It may be a warning of danger.

LOCKOUT DEVICES

A lockout device is a mechanism or arrangement that allows the use of key or combination locks (most commonly padlocks) to hold a switch lever or valve handle in the OFF position. Some switches and valves have lockout devices built in; others must be changed before locks can be used. As a Utilitiesman, you may use lockout devices when working on potentially hazardous equipment, such as high-pressure steam lines, electrically operated equipment, and boilers. The use of a lockout device is a great advantage since the machine or equipment cannot be started up, energized, or activated while you are working on it. The photographs in figure 2-22 will give you an idea of how devices may be used in locking out valves.

Multiple Lock Adapter

It is often an advantage for a lockout device to accommodate more than one padlock. In this way, when you are working on a machine or an item-of equipment with the valve locked off, another person can come along and use the padlock to do other hazardous work on the machine or equipment at the same time, rather than wait until you are finished.

Since most controls are not designed to accommodate more than one padlock at a time, multiple lock adapters, called lockout clamps or tongs, may be used (fig. 2-23). These adapters should be permanently chained to the control, or, alternately, issued to all people with padlocks.

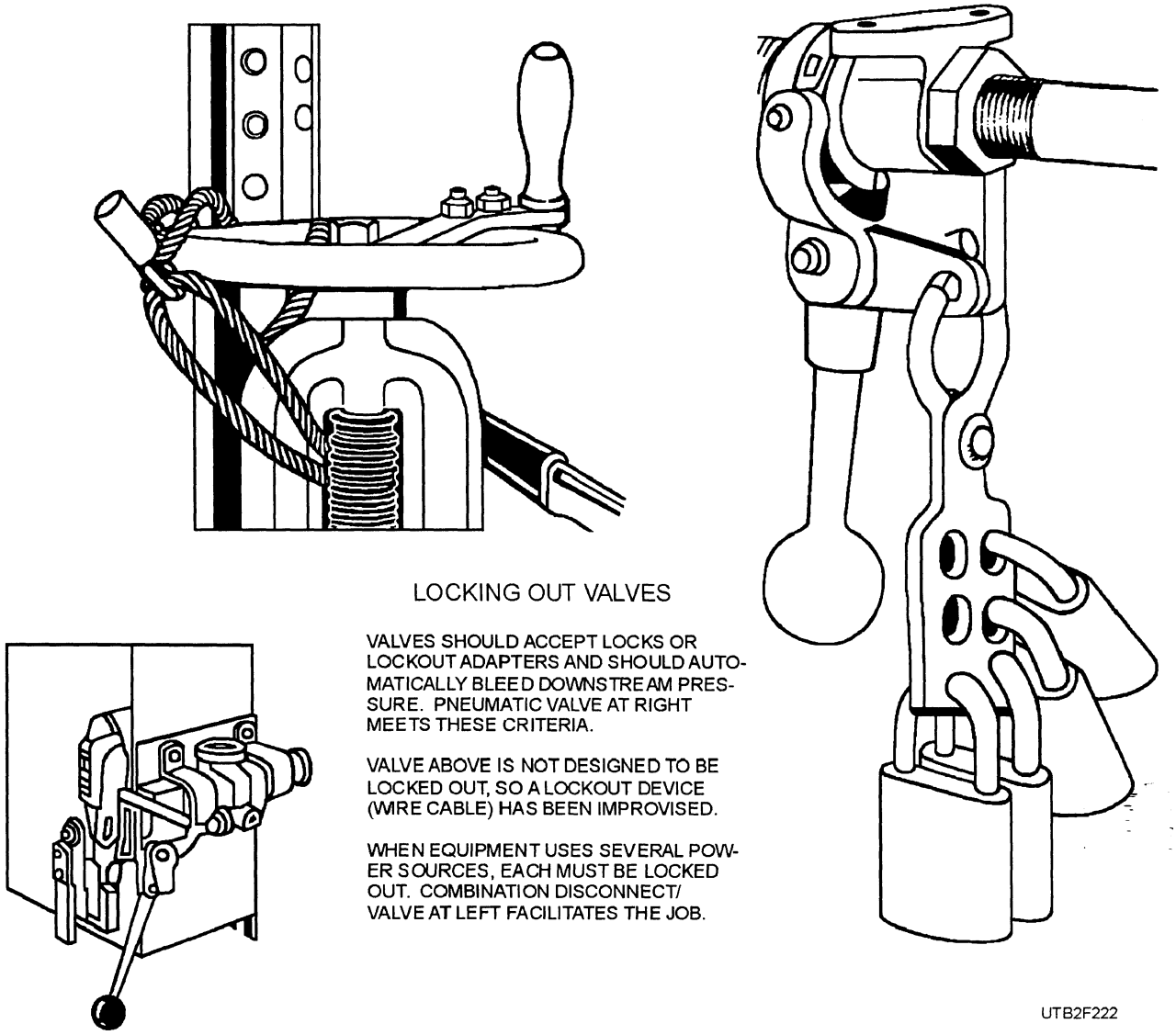

Figure 2-22.—Locking out valves.

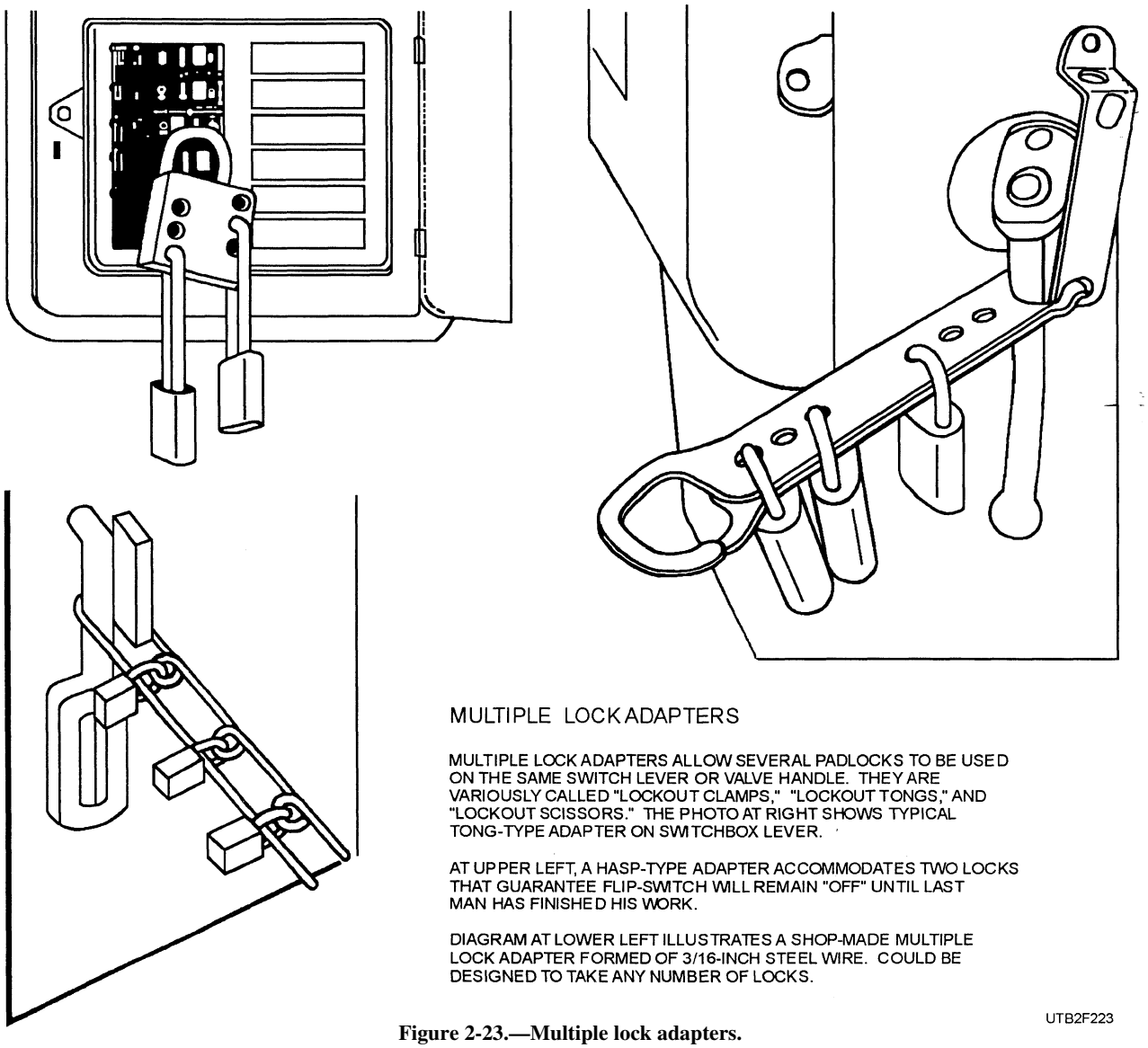

Figure 2-23.—Multiple lock adapters.

Locks

Perhaps you are wondering what kind of lock should be used—key or combination? What person should have a lock? Who should be in possession of the keys or combinations? How should the lock be identified? The answers to these questions may vary from one activity to another, but some guidelines are as follows:

1. Key-operated padlocks are more commonly used than combination locks. Supervisors can control keys easier than combinations.

2. Locks should be issued to every person who works on closed-down equipment. No key (or combination) should fit more than one lock.

3. Only one key should be issued to a person authorized to use the lock. At some activities, the supervisor may be permitted to maintain a duplicate set of keys for locks under his/her control, or a master key. Some activities, however, may have only one lock-one key. In an emergency, bolt cutters may be used to remove a lock. As a word of caution: KEYS AND LOCKS SHOULD NEVER BE LOANED.

4. Locks should identify the user by name, rate, and shop. This information can be stamped into the lock case, stenciled on, or carried on a metal tag fixed to the shackle of the lock. In addition, locks may be color coded to identify the skill or rating of the lock folder, such as UT, CE, or CM. The colors could also follow the hard hat color code.

Lockout Procedures

If locks, lockout devices, and multiple lock adapters are to be effective, they must be used properly on every occasion where they are needed. Make sure that you follow the steps of the lockout procedure below.

1. Before any equipment is locked out, there should be agreement as to the specific machine or unit to be taken out of operation. The supervisor should oversee lockout procedures.

2. Turn off the point-of-operation controls. (Remember that disconnect switches should never be pulled while under load because of the possibility of arcing or even explosion.)

3. See that the main power controls (switch, breaker, or valve) are turned OFF. Where electrical voltages are involved, do NOT attempt this yourself but have it done by a Construction Electrician.

4. After the switch has been opened or the valve closed, the person who will be doing the work should snap the locks on the control lever or multiple lock adapter. At this point, tag the switch, valve, or device being locked. Tags should indicate the type of work being done, approximately how long the job will take, and the name of the supervisor.

5. Try the disconnect or valve to make sure it cannot be moved to ON.

6. Try the machine controls as a test to ensure the main controls are really off.

7. As each person completes work, only that person should remove the lock and supplemental tag. The person removing the last lock should notify the supervisor that the work is finished and the equipment is ready to be placed back in operation.

Q20. When cleaning operations are performed, what basic personal protective equipment should be worn?

Q21. What color should the pull chain handle be painted for the center gauge cock?

Q22. You should never bring a boiler up to pressure unless what valve has been tested?

Q23. Why are key-operatedpadlocks more commonly used than a combination lock for a lockout device?